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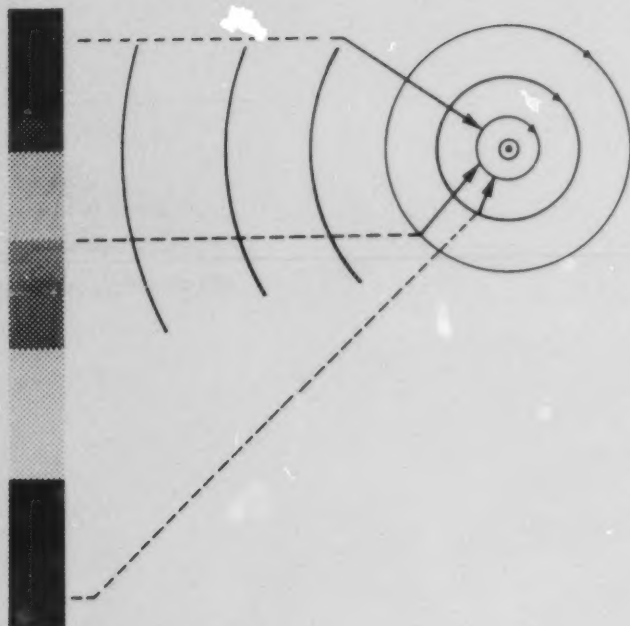
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ABSTRACT

The Physics Unit Tests are designed to assist in the diagnostic evaluation of students' progress in the study of physics during the last two years of secondary schooling. They consist of a collection of 21 separate tests, each related to a different topic, and 21 diagnostic aids corresponding to the tests. The topics covered are: physical measurement, vectors, motion in one dimension, motion on a plane, dynamics, work and energy, linear momentum, oscillations, gravity and Kepler's law, waves, light-reflection and refraction, light-interference diffraction and spectra, models of light, kinetic theory of gases, static charges, electric field and potential difference, current electricity, the magnetic field, induced emf, atomic physics, and quantum physics. (BW)

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ACER Physics Unit Tests

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Unit Tests

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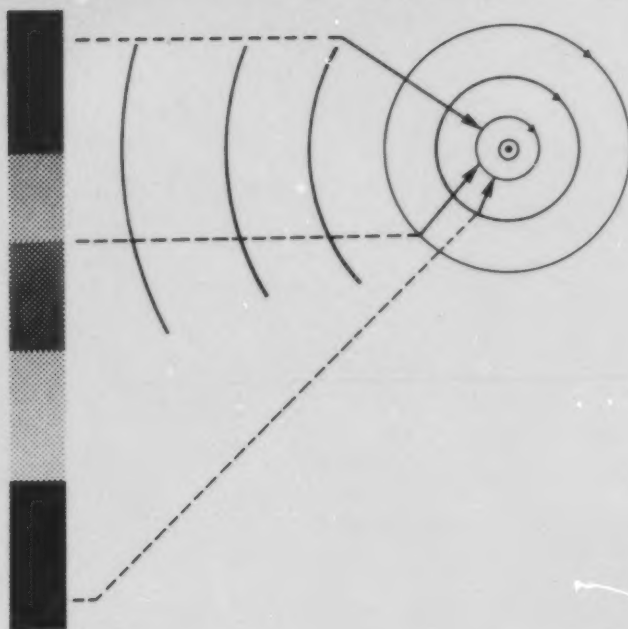
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ACER PHYSICS UNIT TESTS

The ACER Physics Unit Tests consist of the following publications.

- I A collection of tests covering the following topics
 - 1 *Physical measurement*
 - 2 *Vectors*
 - 3 *Motion in one dimension*
 - 4 *Motion on a plane*
 - 5 *Dynamics*
 - 6 *Work and energy*
 - 7 *Linear momentum*
 - 8 *Oscillations*
 - 9 *Gravity and Kepler's laws*
 - 10 *Waves*
 - 11 *Light – reflection and refraction*
 - 12 *Light – interference, diffraction and spectra*
 - 13 *Models of light*
 - 14 *Kinetic theory of gases*
 - 15 *Static charges*
 - 16 *Electric field and potential difference*
 - 17 *Current electricity*
 - 18 *The magnetic field*
 - 19 *Induced EMF*
 - 20 *Atomic physics*
 - 21 *Quantum physics*
- II A collection of 21 Diagnostic Aids covering topics corresponding to tests.
- III Teachers Handbook

ACER Physics Unit Tests symbol adapted from 'Spectrum of hydrogen gas', p. 338, *The Ascent of Man*, J. Bronowski, courtesy Rita Bronowski.



Test 1 Physical measurement

Directions

This test is designed to help you discover any difficulties and misunderstandings you may have in the work that you recently studied in your physics course. It is not intended to allocate a grade or mark to you as a result of taking the test. After completing and marking the test you will be able to make your own record of the questions that you were unable to answer correctly. This record will indicate the parts of the course to which you need to give further attention immediately.

When answering the questions keep these points in mind:

- 1 Do not spend too much time on any one question. If it seems too difficult omit it and go on to the next question.
- 2 For each question, several alternatives are given. You should choose the **best** answer from these alternatives.

The following information may be useful and should always be accepted where relevant.

- 1 Take the acceleration due to gravity, g as 10 m s^{-2} .
- 2 Where required by the calculations, take

$$\sin 30^\circ = \frac{1}{2} = 0.50.$$

$$\sin 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\sin 60^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 30^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\cos 60^\circ = \frac{1}{2} = 0.50.$$

$$\tan 30^\circ = \frac{1}{\sqrt{3}} = 0.58.$$

$$\tan 45^\circ = 1$$

$$\tan 60^\circ = \sqrt{3} = 1.73$$

3. Unless otherwise instructed, neglect air resistance.

Jottings and calculations should be done on a separate sheet of paper.

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NOW TURN THE PAGE AND GO ON WITH THE TEST

- 1 The prefixes kilo, micro, mega and milli refer to the following multiples of units (in that order).

A 10^{-3} , 10^{-6} , 10^6 , 10^3
 B 10^6 , 10^{-3} , 10^3 , 10^{-6}
 C 10^3 , 10^{-6} , 10^6 , 10^{-3}
 D 10^3 , 10^{-6} , 10^{-3} , 10^6

- 2 In a calculation which uses laboratory measurements, the number of significant figures used to express results is determined by

A the number of significant figures in the quantity measured with the greatest accuracy.
 B the sum of the number of significant figures in each of the quantities involved in the calculation.
 C the average number of significant figures in the quantities involved in the calculation.
 D the number of significant figures in the quantity measured with the least accuracy.

- 3 A potential difference of 6.1 volt is applied across a resistor with a resistance of 2.3 ohm. The current in the resistor should be expressed as

A 3 amp. C 2.65 amp.
 B 2.7 amp. D 2.652 amp.

- 4 The volume, V , of a sphere is given by the formula

$$V = \frac{4}{3}\pi r^3$$

where r is the radius.

A sphere has a volume of $4 \times 10^9 \text{ m}^3$. Which one of the following is closest to the correct value of the radius of this sphere?

A 10^8 m C 10^3 m
 B 10^4 m D 10^2 m

- 5 In an experiment, the value of r was determined from the formula $r = \frac{v^2}{2s}$. Measurements of v and s respectively were:

$$v = 2.01 \pm 0.02$$

$$s = 10.340 \pm 0.005$$

A suitable report for the value of r would be

A 0.1954. C 0.195 ± 0.004 .
 B 0.1954 ± 0.005 . D 0.2 ± 0.05 .

- 6 The SI base unit from which all other electrical units are derived is the

A ampere. C elementary electric charge.
 B coulomb. D volt.

- 7 One watt is equivalent to

A $1 \text{ kg m}^2 \text{ s}^{-3}$. C 1 kg m s^{-2} .
 B $1 \text{ kg m}^2 \text{ s}^{-2}$. D $1 \text{ kg m}^2 \text{ s}^{-1}$.

- 8 Which one of the following units is used for electric potential?

A coulomb C newton coulomb⁻¹
 B ampere D volt

- 9 Which one of the following units is used for electric charge?

A ampere C ohm
 B coulomb D volt

- 10 Which one of the following units is equivalent to a coulomb?

A ampere second C elementary charge second⁻¹
 B ampere second⁻¹ D volt second

- 11 One microcoulomb is equal to

A 10^{-9} coulomb. C 10^{-3} coulomb.
 B 10^{-6} coulomb. D 10^6 coulomb.

- 12 The dimensions of force are

A MLT^{-2} . C $M^{-2}LT$.
 B M^2LT^2 . D $ML^{-2}T^{-2}$.

- 13 The formula $P = RQ^x\sqrt{S}$ describes a situation where

P has dimensions T .
 Q has dimensions L^{-2} .
 R is dimensionless (a constant).
 S has dimensions L .

The value of x , the power to which Q is raised, must be

A 1. C $-\frac{1}{2}$.
 B $+\frac{1}{2}$. D -2.

Questions 14-17 refer to the following information:

Einstein derived the following equation which relates energy and mass:

$$E = mc^2$$

where E represents energy, m represents mass, and c represents the speed of light ($c = 3 \times 10^8 \text{ m s}^{-1}$).

- 14 Which one of the following gives the correct SI units for E ?

A $\text{kg m}^2 \text{ s}^{-2}$ C kg m s^{-1}
 B kg m s^{-2} D $\text{kg m}^2 \text{ s}^{-1}$

- 15 In nuclear physics calculations involving the mass of protons, the order of magnitude of m is 10^{-27} SI units. In this case the order of magnitude of E is

A 10^{-43} . C 10^{-19} .
 B 10^{-27} . D 10^{-10} .

- 16 An extension of the Einstein equation is

$$E = mc^2 + T$$

The SI units for T must be

- A kg m s^{-1} . C kg m s^{-2} .
B $\text{kg m}^2 \text{s}^{-2}$. D $\text{kg m}^2 \text{s}^{-1}$.

- 17 In the equation $E = mc^2 + T$, suppose T was a factor which incorporated several quantities, such as

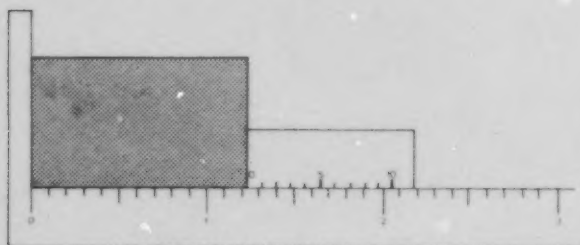
$$T = \frac{1}{2} \rho g h^4$$

where g = acceleration due to gravity
and h = distance.

The SI units of ρ must be

- A kg m s^{-1} . C $\text{kg m}^{-1} \text{s}$.
B kg m s^{-2} . D kg m^{-3} .

- 18 The diagram below represents the measurement of the length of a body using a vernier scale.



The length of the body is closest to

- A 2.18. C 1.24.
B 1.40. D 1.22.

- 19 Which one of the following is equivalent in quantity to one newton?

- A 10 m s^{-2} C 1 kg m s^{-1}
B 1 m s^{-2} D 1 kg m s^{-2}

- 20 Which one of the following is equivalent in quantity to 1 joule?

- A $1 \text{ newton metre}^{-2}$ C 1 newton metre^2
B 1 newton metre D $1 \text{ kilogram metre second}^{-1}$

- 21 One joule is equivalent to

- A $1 \text{ kg m}^2 \text{s}^{-2}$. C 1 kg m s^{-1} .
B 1 kg m s^{-2} . D $1 \text{ kg m}^2 \text{s}^{-1}$

- 22 A rod of length 6.549 cm, when heated, expands to a length of 6.569 cm. The increase in length is most correctly expressed as

- A 0.02000 cm. C 0.020 cm.
B 0.0200 cm. D 0.02 cm.

- 23 One megawatt is equal to

- A 10^{-6} watt. C 10^3 watt.
B 10^{-3} watt. D 10^6 watt.

- 24 Which one of the following units is used for magnetic flux density?

- A newton coulomb $^{-1}$ C weber
B tesla D watt

- 25 Which one of the following units is equivalent to a pascal?

- A newton metre $^{-2}$ C joule second
B newton metre ^{2} D joule second $^{-1}$

- 26 In which one of the following pairs selected from the key below are both members of the pair equivalent to 1 weber?

Key

- | | |
|------------------------------|--|
| I 1 volt second | IV $1 \text{ kg m s}^{-2} \text{ A}$ |
| II 1 volt second $^{-1}$ | V $1 \text{ kg m}^2 \text{s}^{-3} \text{ A}^{-1}$ |
| III 1 newton coulomb $^{-1}$ | VI $1 \text{ kg m}^2 \text{s}^{-2} \text{ A}^{-1}$ |
| | VII $1 \text{ kg m}^2 \text{s}^{-4} \text{ A}$ |
| A I and IV | C II and V |
| B I and VI | D III and VII |

- 27 The mass of the normal family motor car is of the order of

- A 10^2 kg . C 10^4 kg .
B 10^3 kg . D 10^5 kg .

- 28 The quantity 60 km h^{-1} , expressed in m s^{-1} , has a value closest to

- A 100. C 10.
B 60. D 0.1.

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I A series of tests covering the following topics

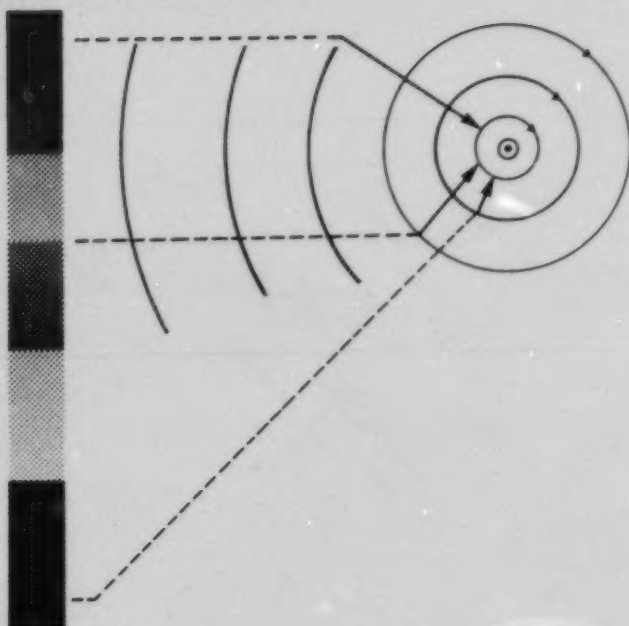
- 1 *Physical measurement*
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- 21 *Quantum physics*

II Teachers Information Booklet

III List of Answers Booklet

ACER Physics Unit Tests

Test 2 Vectors



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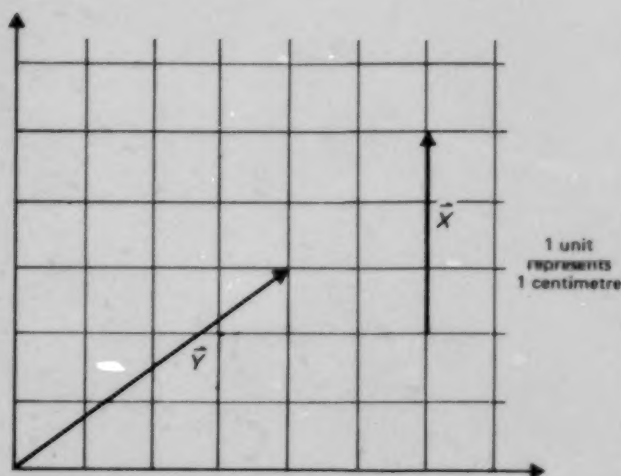
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- 1 Which one of the following sets consists only of scalar quantities?

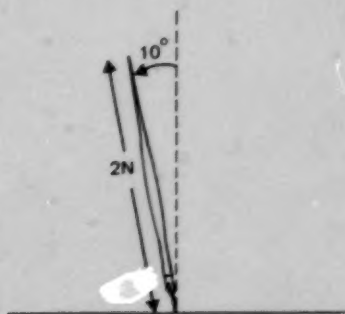
A mass, force, velocity, time
 B power, time, distance, energy
 C velocity, force, momentum, speed
 D weight, speed, kinetic energy, displacement

Questions 2 & 3 refer to the following information:
 Two vectors are represented in the scale diagram below.



- 2 The magnitude of vector $\vec{X} - \vec{Y}$ is
 A 2. C 5.
 B 4. D 8.
- 3 The angle between vector $(\vec{Y} - \vec{X})$ and the horizontal is
 A 0° . C 45° .
 B 30° . D 60° .

Questions 4 & 5 refer to the following information:
 The diagram below represents a pen being pushed with a force of 2 newton acting at an angle of 10° to the vertical.



- 4 The magnitude of the vertical component of the force, in newtons, is
 A $2 \cos 10^\circ$. C $2 \sin 10^\circ$.
 B $\frac{2}{\cos 10^\circ}$. D $\frac{2}{\sin 10^\circ}$.

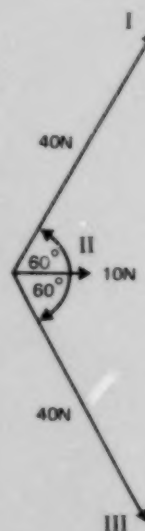
- 5 The magnitude of the horizontal component of the force, in newtons, is

A $2 \cos 10^\circ$. C $2 \sin 10^\circ$.
 B $\frac{2}{\cos 10^\circ}$. D $\frac{2}{\sin 10^\circ}$.

Questions 6 & 7 refer to the following information:

A steel ball moves down an incline with an acceleration of 5 m s^{-2} . The angle of the incline is 30° to the horizontal.

- 6 What is the magnitude, in m s^{-2} , of the horizontal component of the ball's acceleration?
 A 2.5 C 5.8
 B 4.3 D 10
- 7 What is the magnitude, in m s^{-2} , of the vertical component of the ball's acceleration?
 A 2.5 C 5.8
 B 4.3 D 10
- 8 A force which produces uniform circular motion in a body must
 A act in a constant direction and have constant magnitude.
 B be zero.
 C have a constant direction at right angles to the original direction of motion.
 D have a direction always at right angles to the direction of motion at a particular instant and have constant magnitude.
- 9 The diagram shows three forces acting at a point represented by the vectors I, II, and III.

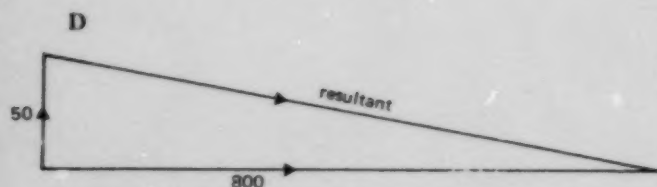
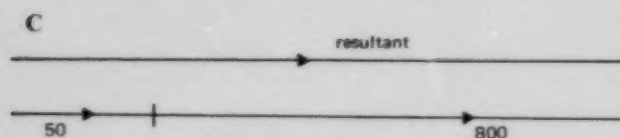
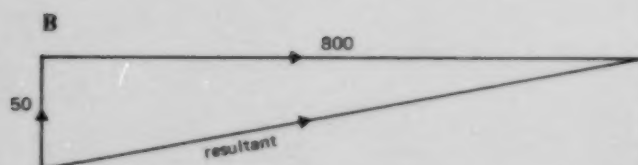
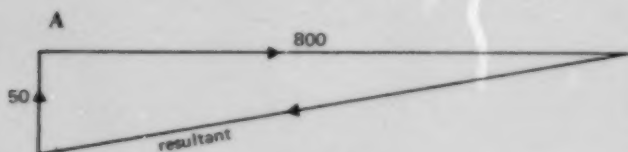


- The resultant of these three vectors is a vector
 A 90 N in the direction of II.
 B 50 N in the direction of II.
 C 10 N in the direction of II.
 D 10 N in the opposite direction of II.

Questions 10-12 refer to the following information:

A plane is flying due east at an airspeed of 800 km h^{-1} when it encounters a cross wind from a direction due south, blowing at 50 km h^{-1} .

- 10 Which one of the following diagrams correctly gives the resultant velocity of the plane relative to the earth?



- 11 The magnitude of the resultant velocity is approximately

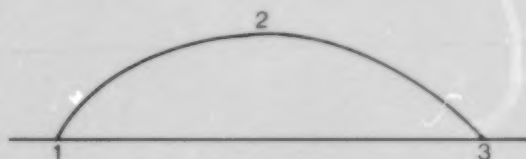
A 798 km h^{-1} C 802 km h^{-1}
B 800 km h^{-1} D 850 km h^{-1}

- 12 The resultant direction of the plane's motion is

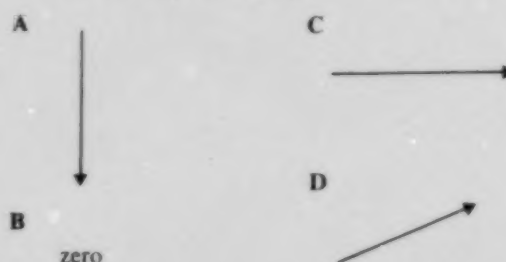
A due east.
B due south.
C slightly north of due east.
D slightly south of due east.

Questions 13 & 14 refer to the following information:

The diagram represents the curved path of a golf ball through the air. The ball leaves the ground at point 1 and strikes the ground again at point 3. Point 2 is the highest point on the path.



- 13 The instantaneous velocity of the ball at point 2 could be represented by



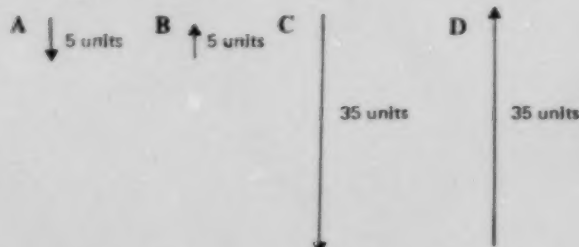
- 14 The magnitude of the displacement of the ball from point 1 to point 2 would be given by

A the length of the straight line joining points 1 and 2.
B the length of the curved path joining points 1 and 2.
C the horizontal distance from point 1 to the position on the ground vertically below point 2.
D none of the above.

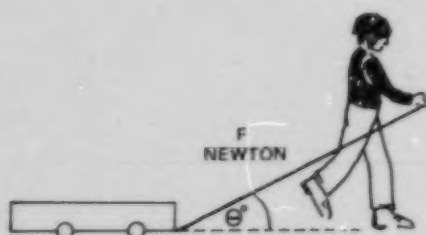
- 15 The velocities of a ball immediately before and after bouncing vertically on the ground are represented on a certain scale by vectors $\vec{X}$ and $\vec{Y}$ respectively.



Which one of the following vectors (on the same scale) represents the change in the velocity of the ball?



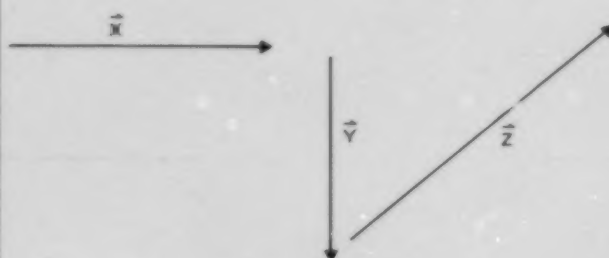
Questions 16 & 17 refer to the following information:



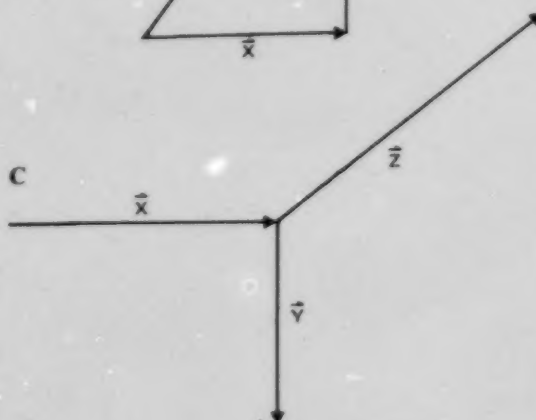
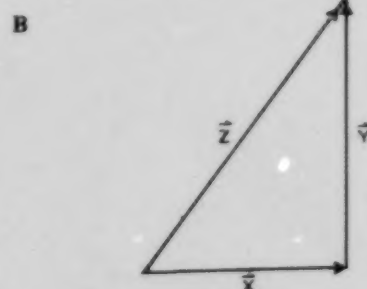
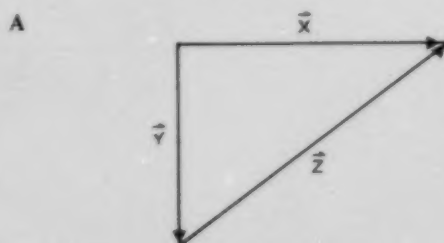
A boy pulls on a trolley with a force of F newton at an angle of θ° to the direction of motion. The mass of the trolley is m kg, and $g \text{ m s}^{-2}$ is the gravitational acceleration.

- 16 The magnitude of the component of the force in the direction of motion is
 A zero. C $F \cos \theta^\circ$ newton.
 B $F \sin \theta^\circ$ newton. D $F \tan \theta^\circ$ newton.
- 17 The upward force of the ground on the trolley has a value of
 A zero. C $mg - F \sin \theta^\circ$ newton.
 B mg newton. D $mg - F \cos \theta^\circ$ newton.

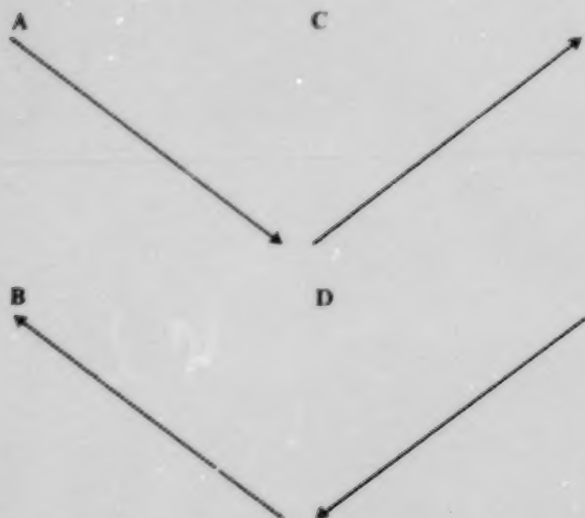
Questions 18-21 refer to the following information:
 Three different vectors are represented below.



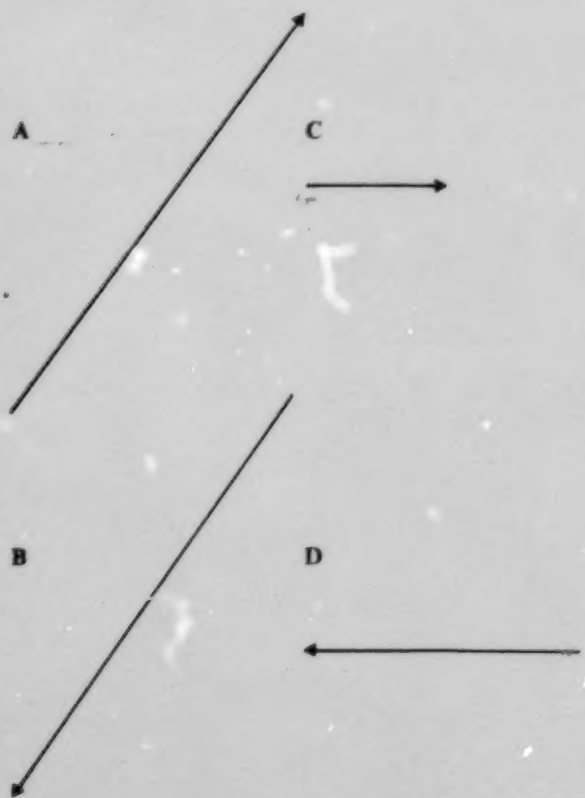
- 18 Which one of the following diagrams is a correct method for finding the vector sum $\vec{X} + \vec{Y} + \vec{Z}$?



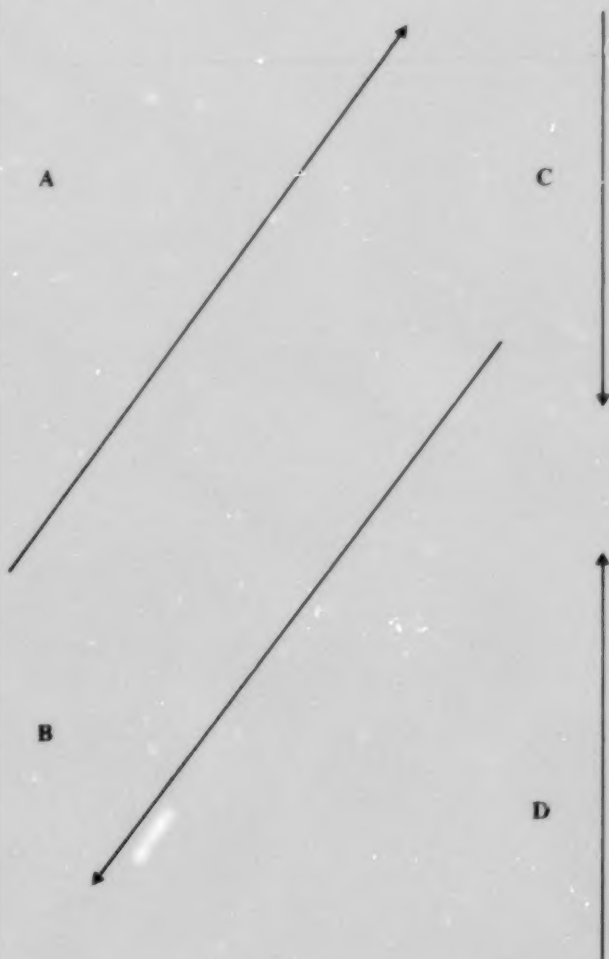
19 Which one of the following vectors best represents the vector $\vec{X} - \vec{Y}$?



20 Which one of the following vectors best represents the vector $\vec{Y} - \vec{Z}$?



21 Which one of the following diagrams best represents the vector $\vec{X} + \vec{Y} - \vec{Z}$?



- 22 A hydrogen molecule travelling at 1000 m s^{-1} east strikes the wall of a container and rebounds at 1000 m s^{-1} west. Its change in velocity is
 A zero. C 2000 m s^{-1} east.
 B 1000 m s^{-1} west. D 2000 m s^{-1} west.

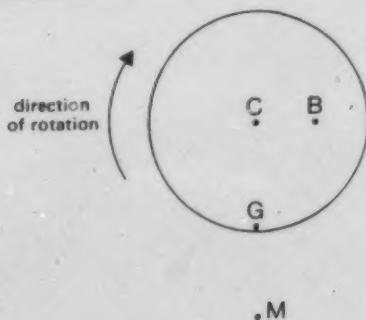
- 23 Another hydrogen molecule travels at 1000 m s^{-1} north east, hits the wall and rebounds at 1000 m s^{-1} north west. The change in velocity of the molecule is
 A zero. C 1414 m s^{-1} east.
 B 1414 m s^{-1} west. D 2000 m s^{-1} west.

- 24 Two masses, P and Q, are moving with velocities $\vec{v}_p$ and $\vec{v}_q$. To determine the velocity of Q relative to P, it would be necessary to find
 A $\vec{v}_p + \vec{v}_q$ C $\vec{v}_q - \vec{v}_p$
 B $\vec{v}_p - \vec{v}_q$ D $\frac{\vec{v}_p + \vec{v}_q}{2}$

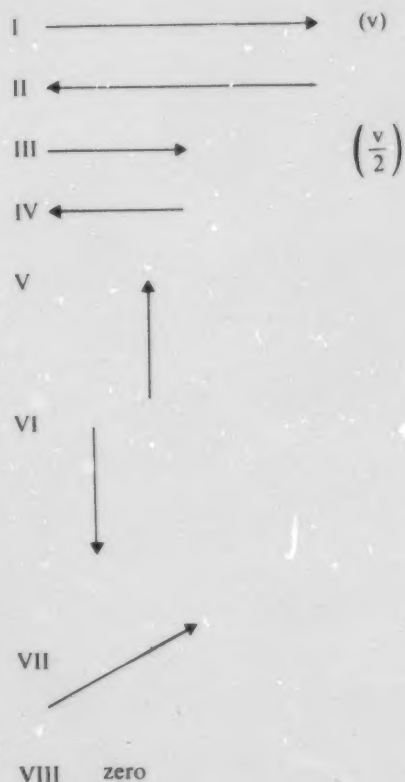
- 25 Car A is moving at a speed of 60 km h^{-1} near car B which is travelling at 100 km h^{-1} . Which one of the following is closest to the correct value for the speed of car A relative to car B when car A is travelling due north and car B south east?
 A 160 km h^{-1} C 70 km h^{-1}
 B 150 km h^{-1} D 40 km h^{-1}

Questions 26–28 refer to the following information:

When a merry-go-round rotates, a point on its rim travels at a linear speed of $v \text{ m s}^{-1}$. A girl (G) rides on the rim of the merry-go-round, and a boy (B) rides half-way between the centre and the rim. An observer stands at position M.



The following key lists various vectors.



The following questions (26–28) refer to the instant when B, G, and M are located as shown in the above diagram.

- 26 Which one of the following vectors represents the velocity of M relative to G?
 A I C V
 B II D VIII
- 27 Which one of the following vectors represents the velocity of B relative to M?
 A IV C VI
 B V D VII
- 28 Which one of the following vectors represents the velocity of B relative to G?
 A V C VII
 B VI D VIII

ACER PHYSICS UNIT TESTS

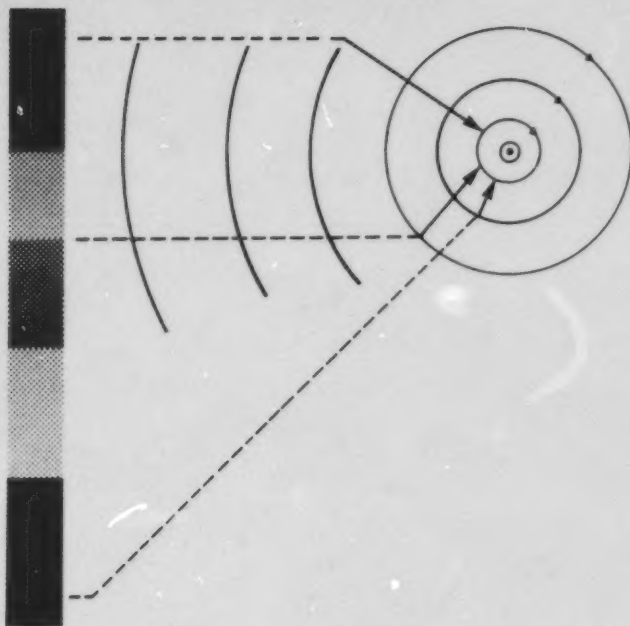
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- 1 *Physical measurement*
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- 17 *Current electricity*
- 18 *The magnetic field*
- 19 *Induced emf*
- 20 *Atomic physics*
- 21 *Quantum physics*

II Teachers Information Booklet

III List of Answers Booklet



Test 3 Motion in one dimension

Directions

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- 2 For each question, several alternatives are given. You should choose the **best** answer from these alternatives.

The following information may be useful and should always be accepted where relevant.

- 1 Take the acceleration due to gravity, g as 10 m s^{-2} .
- 2 Where required by the calculations, take

$$\sin 30^\circ = \frac{1}{2} = 0.50.$$

$$\sin 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\sin 60^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 30^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\cos 60^\circ = \frac{1}{2} = 0.50.$$

$$\tan 30^\circ = \frac{1}{\sqrt{3}} = 0.58.$$

$$\tan 45^\circ = 1$$

$$\tan 60^\circ = \sqrt{3} = 1.73$$

3. Unless otherwise instructed, neglect air resistance.

Jottings and calculations should be done on a separate sheet of paper.

Do not write on this test booklet
NOW TURN THE PAGE AND GO ON WITH THE TEST

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Questions 1-4 refer to the following information:

A ball is thrown vertically upwards and returns to the thrower's hand. Neglect air resistance when determining answers.

- 1 During its flight, the velocity of the ball is
 - A constant.
 - B increasing.
 - C decreasing.
 - D neither A nor B nor C.
- 2 During its flight, the speed of the ball is
 - A constant.
 - B increasing.
 - C decreasing.
 - D increasing and decreasing.
- 3 The magnitude of the acceleration throughout the flight is
 - A a non-zero constant.
 - B zero.
 - C increasing.
 - D decreasing.
- 4 The direction of the acceleration is
 - A upwards and constant.
 - B downwards and constant.
 - C upwards and changing.
 - D downwards and changing.

Questions 5 & 6 refer to the following information:

A stone dropped from rest down a mine shaft takes three seconds to reach the bottom. Neglect air resistance when determining answers.

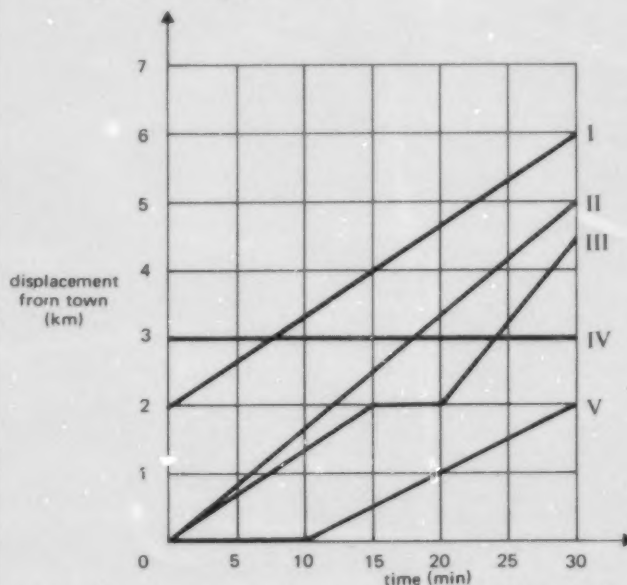
- 5 What is the depth of the mine shaft?

A 15 m	C 45 m
B 30 m	D 90 m
- 6 What is the magnitude of the velocity of the stone at the instant before striking the bottom?

A 15 m s^{-1}	C 45 m s^{-1}
B 30 m s^{-1}	D 90 m s^{-1}

Questions 7-10 refer to the following information and graph:

The graph shows the varying positions of five cyclists (I-V) recorded over a 30 minute period on a straight road leading from a town. The town was taken as the zero point for displacement.



- 7 Which cyclist was the last to leave the town?

A I	D IV
B II	E V
C III	
- 8 Which cyclist attained the greatest speed during the 30 minute period recorded?

A I	D IV
B II	E V
C III	
- 9 Which cyclists were stationary at some time during the interval between 5 and 25 minutes?

A III and IV only	C III and V only
B IV and V only	D III, IV and V only
- 10 Which one of the following cyclists was **not** at the town at the start of the 30 minute period?

A II	C IV
B III	D V

Questions 11 & 12 refer to the following four statements concerning an object's speed:

- I The average speed can be calculated by dividing the total distance covered by the object by the time taken to travel that distance.
- II The object's speed at any given time is equal to its average speed.
- III The object's speed halfway through the time interval is given by the average speed.
- IV The average speed of an object is half the speed of the object at the end of the time interval.

11 Which one of the statements is always correct?

- A I
- B II
- C III
- D IV

12 If an object is travelling with constant acceleration, which two of the statements are correct?

- A I and III
- B II and III
- C III and IV
- D I and IV

Questions 13 & 14 refer to the following information:

An object slows down at a uniform rate from 30 metres per second to 10 metres per second in 5.0 seconds.

13 What was the acceleration of the object?

- A -8 m s^{-2}
- B -6 m s^{-2}
- C -4 m s^{-2}
- D -2 m s^{-2}

14 How far did the object travel during the five seconds?

- A 50 m
- B 100 m
- C 125 m
- D 200 m

15 An object with initial velocity of p metres per second accelerates with a constant acceleration of r metres per second per second. After k seconds, the object has travelled a distance of f metres and has attained a velocity of q metres per second.

The following equations give alternative combinations of these variables.

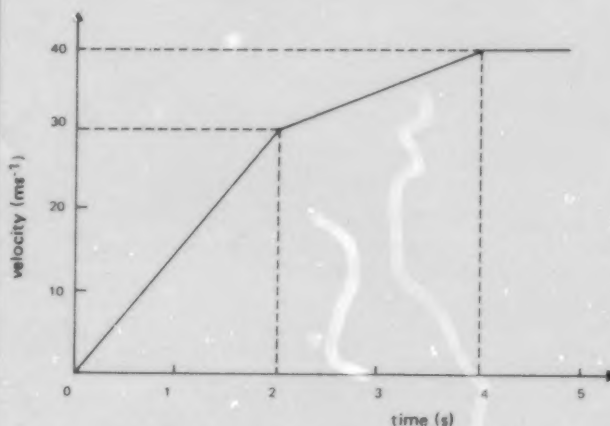
- I $p = q + rk$
- II $f = pk + \frac{1}{2}rk^2$
- III $f = \left(\frac{p+q}{2}\right)k$
- IV $q^2 = p^2 + 2rk$

Which of the equations correctly relate the variables?

- A II only
- B I and II only
- C II and III only
- D II and IV only

Questions 16-18 refer to the following information:

The graph shows the velocity of a cart moving in a straight line over a five second period.



16 How many metres has the object travelled after two seconds?

- A 15 m
- B 30 m
- C 45 m
- D 60 m

17 How many metres has the object travelled after four seconds?

- A 85 m
- B 100 m
- C 110 m
- D 130 m

18 What is the magnitude of the acceleration of the object at the time three seconds after starting?

- A 5 m s^{-2}
- B 10 m s^{-2}
- C 20 m s^{-2}
- D unable to be determined from the information given

Questions 19 & 20 refer to the following information:
A ball which is being uniformly accelerated is observed for three consecutive seconds of its motion. During the first second in which observations are made, it travels 6.0 metres and during the third second it travels 16 metres.

- 19 What is the average speed of the ball during the second second?

A 6 m s^{-1}
B 11 m s^{-1}
C 16 m s^{-1}
D unable to be determined from the information given

- 20 What is the acceleration of the ball?

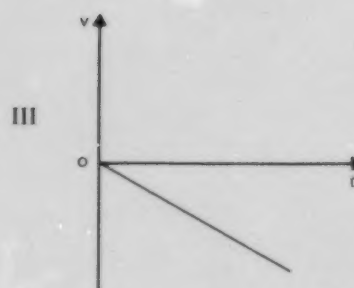
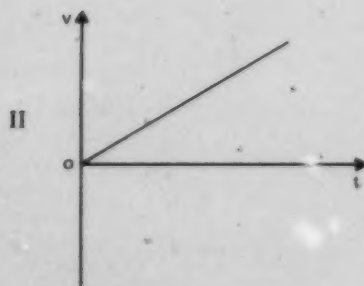
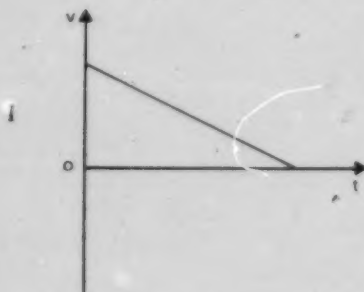
A 5 m s^{-2} C 10 m s^{-2}
B 6 m s^{-2} D 11 m s^{-2}

- 21 The acceleration-time graph for a cart is shown in the diagram.

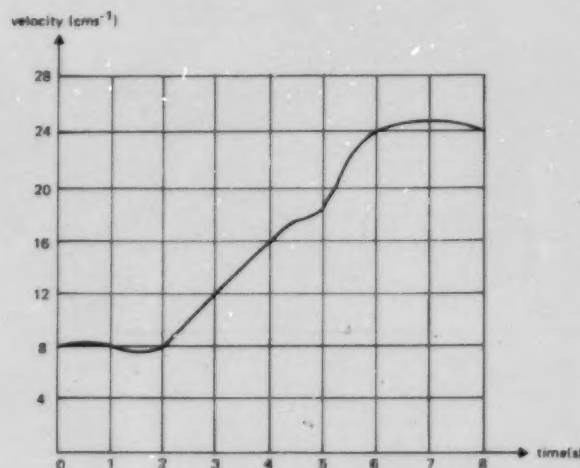


Which of the following diagrams represents the velocity-time graph describing the cart's motion?

A I only C both II and III
B II only D both I and III



Questions 22 & 23 refer to the following information:
The diagram represents the velocity-time graph for an object moving along a straight path.



- 22 How far had the object travelled after four seconds?

A 19.8 cm C 39.6 cm
B 32.0 cm D 48.0 cm

- 23 Which of the following is the best estimate of the instantaneous acceleration of the object after six seconds?

A 0.45 cm s^{-2} C 4.0 cm s^{-2}
B 1.8 cm s^{-2} D 24.0 cm s^{-2}

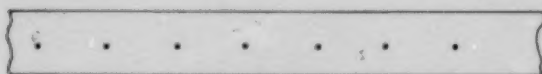
- 24 The following diagram represents a multiflash photographic record of a cart travelling with a constant acceleration, a .



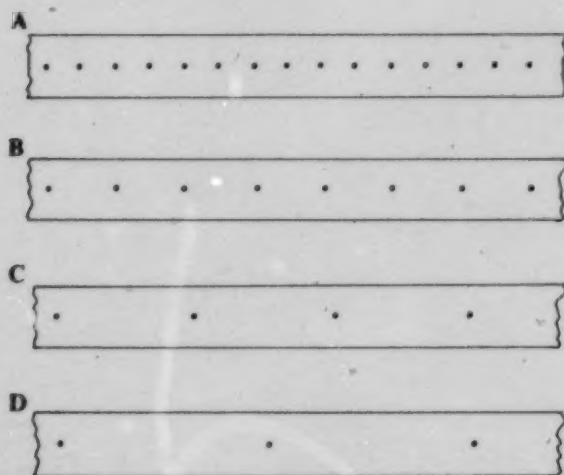
Assume that the diagrams are drawn to a uniform scale and that the frequency of the flashing light does not change. Which one of the following diagrams best represents a cart showing an acceleration, $2a$?



- 25 The following diagram represents a ticker-timer record produced by a cart travelling with a constant speed, v .



Assume that the frequency of the timer does not change. Which one of the following diagrams best represents a record of a cart travelling with a constant speed, $2v$?



- Questions 26 & 27 refer to the following information:
The diagram shows the marks recorded on a tape as it was pulled in one direction beneath a stationary vibrating marker.



The tape was 10 metres long and was pulled through the marker in two seconds, while the marker vibrated at a constant rate of 10 cycles per second. Assume that the diagram is drawn to a known scale.

- 26 The velocity of the tape was constant during the marking of
A section I only.
B section III only.
C sections III and IV only.
D sections I, III and V only.
- 27 The magnitude of the acceleration of the tape was greatest during the marking of section
A II.
B III.
C IV.
D V.

ACER PHYSICS UNIT TESTS

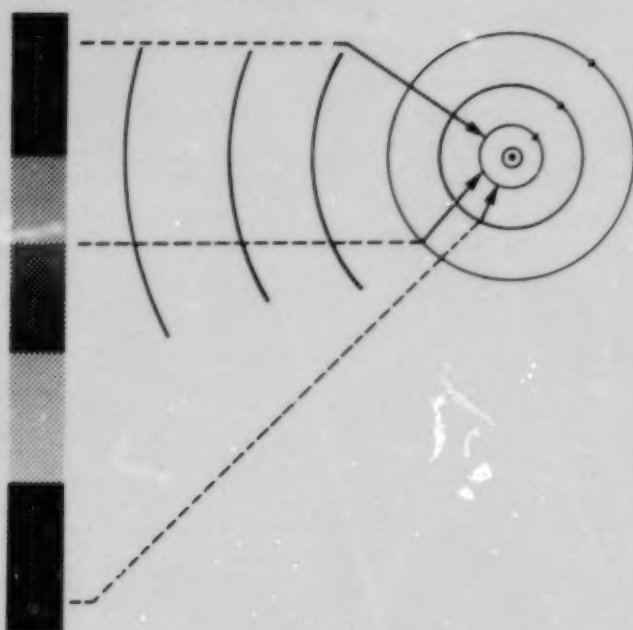
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II Teachers Information Booklet

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Test 4 Motion on a plane

Directions

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$$\sin 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\sin 60^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 30^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\cos 60^\circ = \frac{1}{2} = 0.50.$$

$$\tan 30^\circ = \frac{1}{\sqrt{3}} = 0.58.$$

$$\tan 45^\circ = 1$$

$$\tan 60^\circ = \sqrt{3} = 1.73$$

3. Unless otherwise instructed, neglect air resistance.

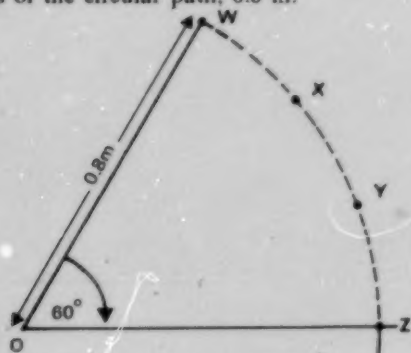
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- 1 A body moves in a circular path at constant speed. Which one of the following statements regarding the motion of the body is true?
- A If the speed is doubled for a given radius, the centripetal force is also doubled.
 - B The centripetal force is directed at right angles to the instantaneous velocity.
 - C If the mass of the body is increased by a factor of three, the centripetal force required to maintain the same motion is increased by a factor of nine.
 - D If the radius is doubled without changing the instantaneous speed, the centripetal acceleration will be doubled.

Questions 2-4 refer to the following information:

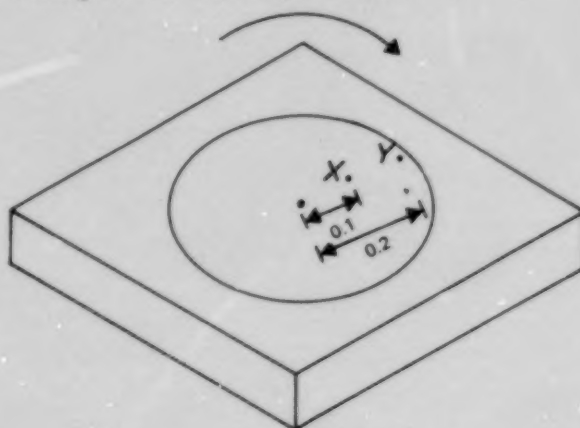
The positions of an object in uniform circular motion were recorded at 0.2 s intervals, as shown by the points W, X, Y, and Z. The mass of the object was 2 kg and the radius of the circular path, 0.8 m.



- 2 One of the following statements is false. Which one?
- A The instantaneous speed of the object is the same at X as it is at Z.
 - B The direction of the velocity of the object when at Z is at right angles to the line OZ.
 - C The acceleration at X has the same magnitude as the acceleration at Z.
 - D The accelerating force acting on the object at W is directed along the tangent to the circle at that point.
- 3 The frequency of revolution for the object is given by
- A 5 s^{-1}
 - B $\frac{18}{5} \text{ s}^{-1}$
 - C $\frac{5}{18} \text{ s}^{-1}$
 - D $\frac{2}{45} \text{ s}^{-1}$
- 4 The instantaneous speed at point X is given by
- A $\frac{4\pi}{9} \text{ m s}^{-1}$
 - B $\frac{20}{81} \pi^2 \text{ m s}^{-1}$
 - C $\frac{24}{25} \text{ m s}^{-1}$
 - D neither A nor B nor C as it cannot be determined from the data given.

Question 5-9 refer to the following information:

Two identical coins, X and Y, are fixed 0.10 m and 0.20 m respectively from the centre of a record turntable rotating at 45 revolutions per minute.



- 5 The ratio $\frac{\text{frequency of rotation of X}}{\text{frequency of rotation of Y}}$ is
- A $\frac{1}{2}$
 - B $\frac{1}{1}$
 - C $\frac{2}{1}$
 - D $\frac{3}{1}$
- 6 The ratio $\frac{\text{speed of X}}{\text{speed of Y}}$ is
- A $\frac{1}{2}$
 - B $\frac{1}{1}$
 - C $\frac{2}{1}$
 - D $\frac{3}{1}$
- 7 The ratio $\frac{\text{acceleration of X}}{\text{acceleration of Y}}$ is
- A $\frac{1}{2}$
 - B $\frac{1}{1}$
 - C $\frac{2}{1}$
 - D $\frac{3}{1}$
- 8 The ratio $\frac{\text{centripetal force acting on X}}{\text{centripetal force acting on Y}}$ is
- A $\frac{1}{2}$
 - B $\frac{1}{1}$
 - C $\frac{2}{1}$
 - D $\frac{3}{1}$
- 9 The turntable is now switched to rotate at $33\frac{1}{3}$ revolutions per minute. Which ratios will now be different?
- A speed only
 - B acceleration only
 - C acceleration and centripetal force only
 - D frequency of rotation, speed, acceleration and centripetal force
 - E None of the ratios will be changed.

- 10 Travelling at constant speed, a cyclist rides one training lap of a circular track of circumference 200 m in 20 s. The magnitude of his acceleration is

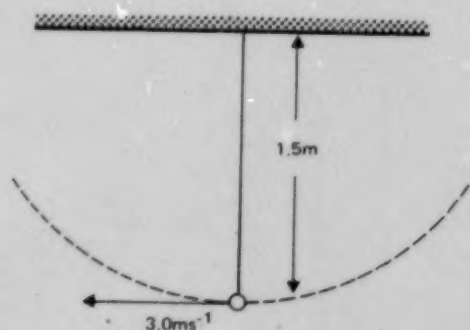
A 10. C π .
B π^2 . D 0.

- 11 A car of mass 500 kg negotiates a curve of radius 50 m at a speed of 6.0 m s^{-1} . The frictional force between the horizontal road surface and the car, if no sliding occurs, is closest to

A 60 N. C 700 N.
B 360 N. D 4200 N.

Questions 12 & 13 refer to the following information:

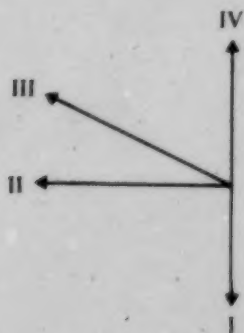
A pendulum bob of mass 4.0 kg is attached to the end of a stationary light string 1.5 m long. The bob is made to swing so that it passes through the lowest position of its path with a speed of 3.0 m s^{-1} .



- 12 What is the magnitude of the force exerted by the string on the bob when the bob is at its lowest position?

A 16 N C 46 N
B 40 N D 64 N

- 13 What is the direction of the resultant force on the bob?

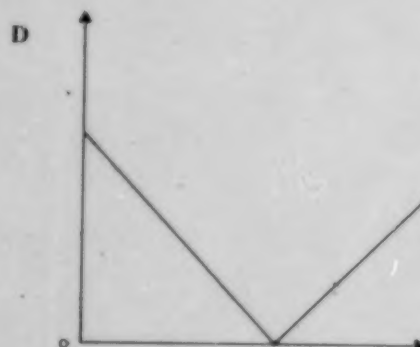
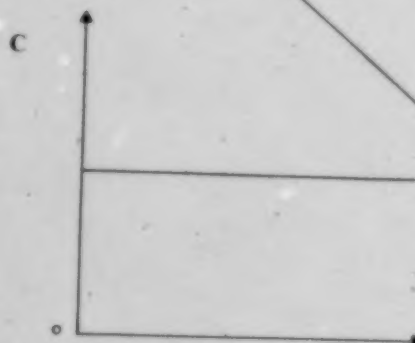
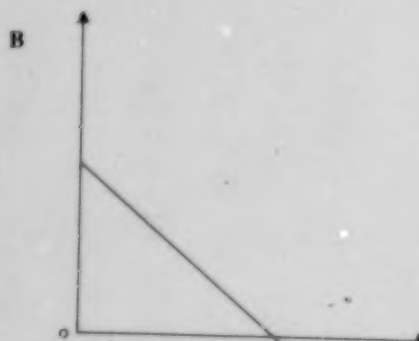
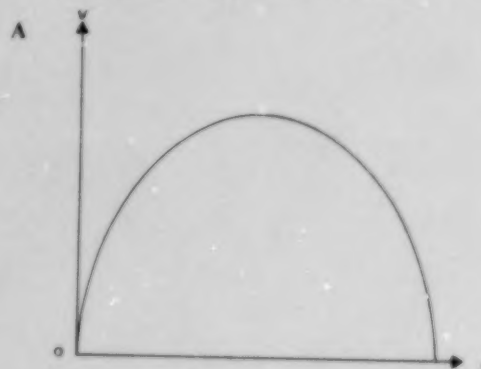


A I C III
B II D IV

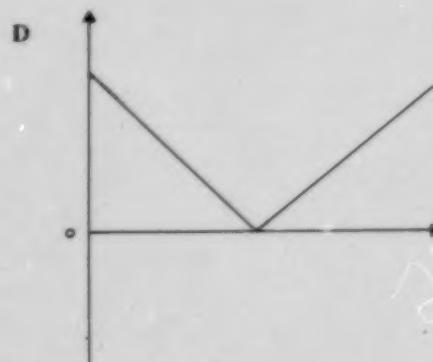
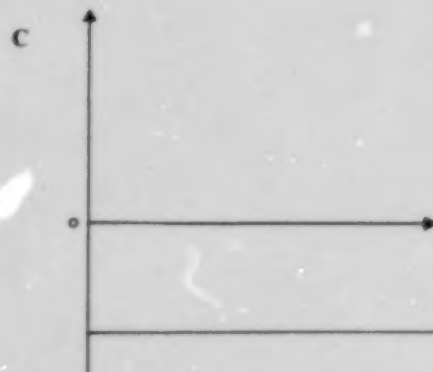
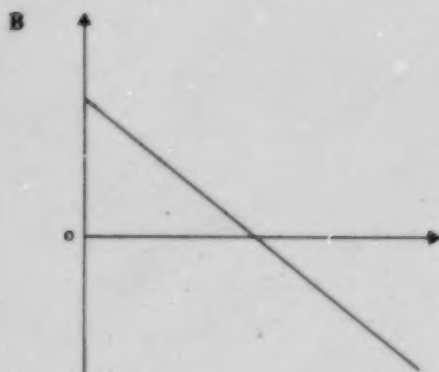
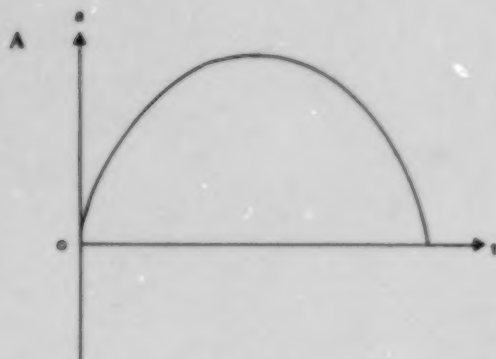
Questions 14 & 15 refer to the following information:

A ball is thrown vertically upwards. Assume the positive direction is up and ignore air resistance.

- 14 Which of the following velocity-time graphs best represents the motion of the ball from the time it leaves the hand to the time it returns?

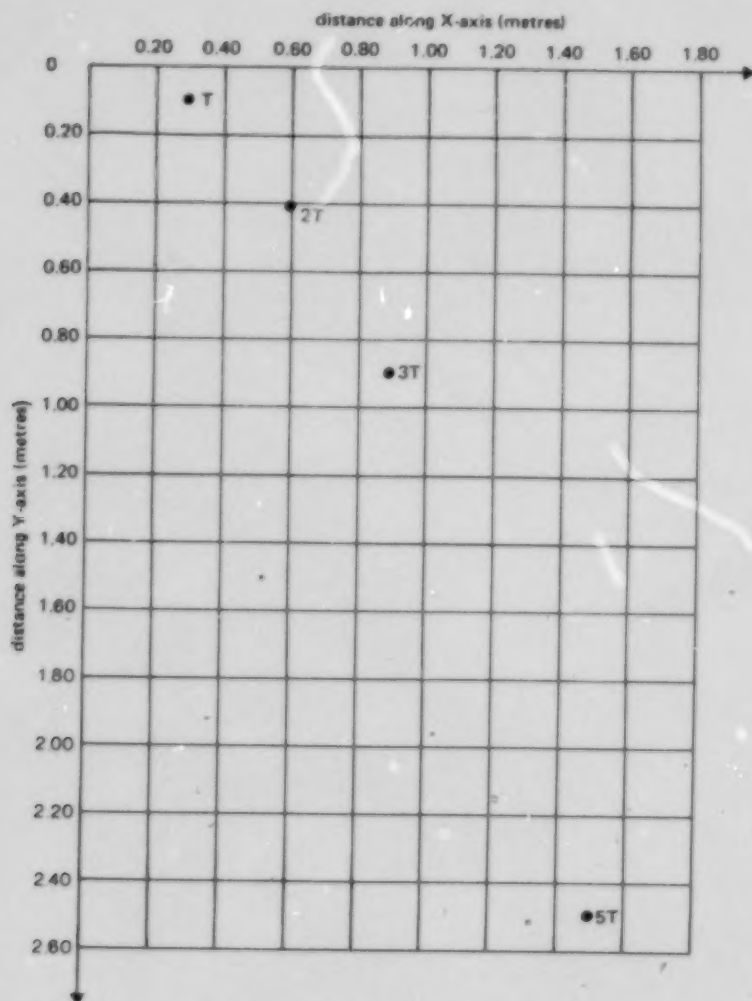


- 15 Which of the following acceleration-time graphs best represents the acceleration of the ball from the time it leaves the hand to the time it returns?



Questions 16-20 refer to the following information:

A sphere was projected horizontally from a height above a floor, and its position recorded by a camera at the end of a number of equal time intervals of length T seconds. These positions are represented in the diagram, where the origin of the axes represents the point of projection. The position at the end of the fourth interval is not indicated.

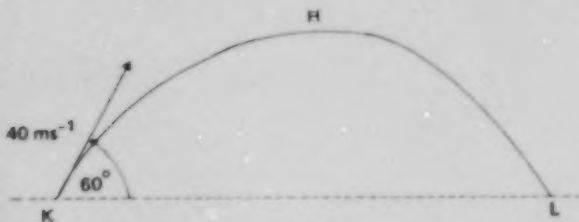


- 16 What is the X value of the sphere's position at the end of the fourth time interval?
- A 1.10 C 1.30
B 1.20 D 1.40
- 17 What is the Y value of the sphere's position at the end of the fourth time interval?
- A 1.40 C 2.00
B 1.60 D 2.30
- 18 What is the vertical component of the average velocity (in m per time interval) of the sphere during the third time interval?
- A 0.50 C 0.30
B 0.40 D 0.20

- 19 If the sphere has a mass of M kg, what is the horizontal component of the net force acting on the body at position $5T$?
- A 0 N C $1.5M$ N
B $0.1M$ N D $10M$ N
- 20 If the sphere has a mass of M kg, what is the vertical component of the net force acting on the body at position $5T$?
- A 0 N C $1.5M$ N
B $0.1M$ N D $10M$ N

Questions 21–25 refer to the following information:

A stone is thrown at an angle of 60° to the horizontal, with an initial velocity of 40 m s^{-1} at point K . The maximum height reached in the trajectory is shown by the point H . Ignore air resistance.



- 21 At H , the magnitude of the vertical component of the velocity of the stone is
 A 0 m s^{-1} . C 20 m s^{-1} .
 B $\frac{20}{\sqrt{3}} \text{ m s}^{-1}$. D $20\sqrt{3} \text{ m s}^{-1}$.
- 22 At H , the total acceleration of the stone is
 A 0 m s^{-2} . C 10 m s^{-2} down.
 B 10 m s^{-2} up. D $20\sqrt{3} \text{ m s}^{-2}$ to the right.
- 23 At H , the horizontal component of the velocity of the stone is
 A 0 m s^{-1} . C 20 m s^{-1} .
 B $\frac{20}{\sqrt{3}} \text{ m s}^{-1}$. D $20\sqrt{3} \text{ m s}^{-1}$.
- 24 Just prior to impact at L , the acceleration of the stone is
 A 0 m s^{-2} . C 10 m s^{-2} up.
 B 10 m s^{-2} down. D 40 m s^{-2} , 60° to the horizontal downwards.

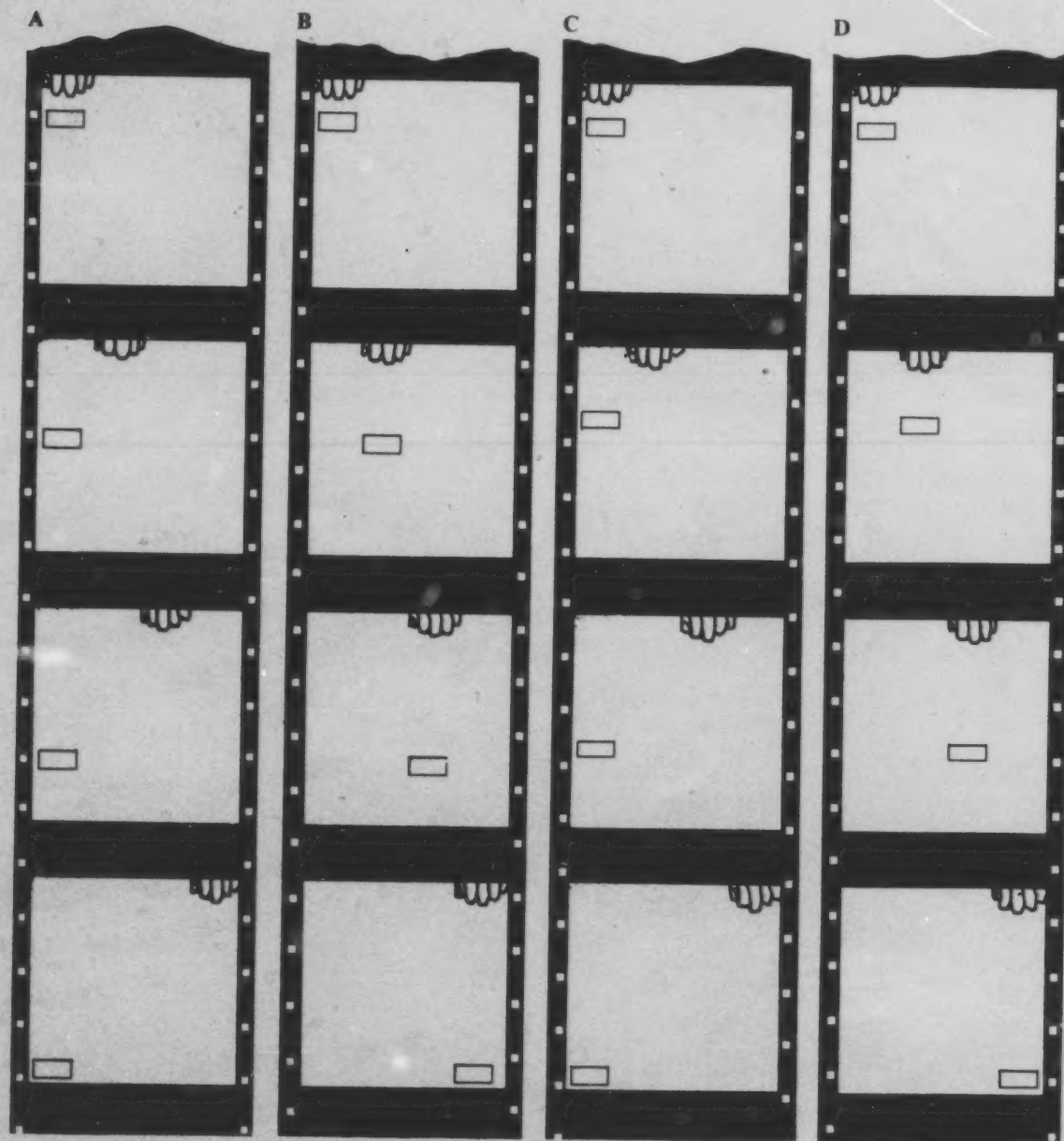
- 25 Just prior to impact at L , the magnitude of the vertical component of the downward velocity of the stone is
 A 20 m s^{-1} . C 10 m s^{-1} .
 B $\frac{20}{\sqrt{3}} \text{ m s}^{-1}$. D $20\sqrt{3} \text{ m s}^{-1}$.
- 26 Which one of the following characteristics is common to both projectile motion and uniform circular motion?
 A The acceleration is always constant.
 B The acceleration is at right angles to the direction of motion.
 C The magnitude of the acceleration is constant.
 D The acceleration is directly proportional to the square of the instantaneous velocity.

Questions 27–29 refer to the following information:

A boy holds a brick in his hand as he walks horizontally at constant velocity. As he travels, he drops the brick. Neglect air resistance.

- 27 After leaving the hand, the magnitude of the horizontal component of the acceleration of the brick is
 A increasing. C zero.
 B decreasing. D constant, but not zero.
- 28 The magnitude of the vertical component of the acceleration of the brick is
 A increasing. C zero.
 B decreasing. D constant, but not zero.

29 Which of the following sets of motion-picture stills best represents the position of the boy's hand and the brick?



30 A boy standing at the top of a hill has a stone and a stop-watch. He projects the stone horizontally and starts his watch. The stone takes 5 seconds to reach the ground at the bottom of the hill. Take $g = 10 \text{ m s}^{-2}$. The height of the hill from which the stone was projected is

- A 50 m.
- B 125 m.
- C 250 m.
- D unable to be determined from the information given.

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I A series of tests covering the following topics

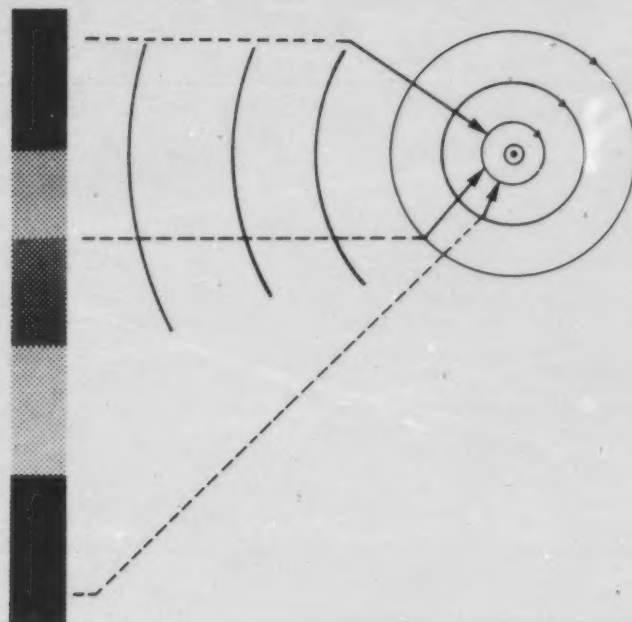
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ACER Physics Unit Tests

Test 5 Dynamics



Directions

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The following information may be useful and should always be accepted where relevant.

- 1 Take the acceleration due to gravity, g as 10 m s^{-2} .
- 2 Where required by the calculations, take

$$\sin 30^\circ = \frac{1}{2} = 0.50.$$

$$\sin 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\sin 60^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 30^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\cos 60^\circ = \frac{1}{2} = 0.50.$$

$$\tan 30^\circ = \frac{1}{\sqrt{3}} = 0.58.$$

$$\tan 45^\circ = 1$$

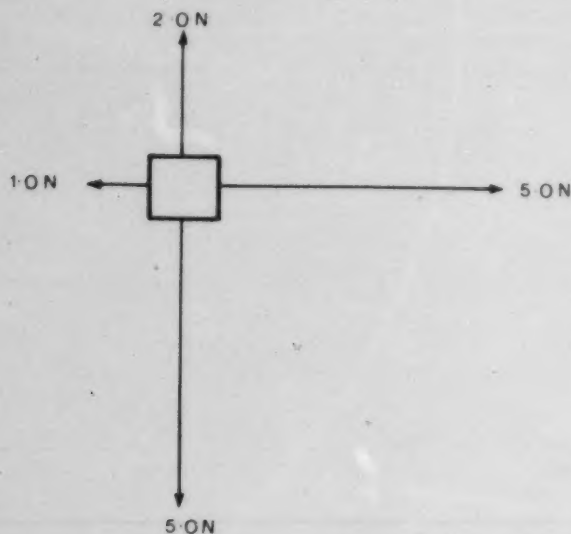
$$\tan 60^\circ = \sqrt{3} = 1.73$$

- 3 Unless otherwise instructed, neglect air resistance.

Jottings and calculations should be done on a separate sheet of paper.

Do not write on this test booklet
NOW TURN THE PAGE AND GO ON WITH THE TEST

Questions 1 & 2 refer to the following information:
The only external forces acting on a block are shown in the diagram.



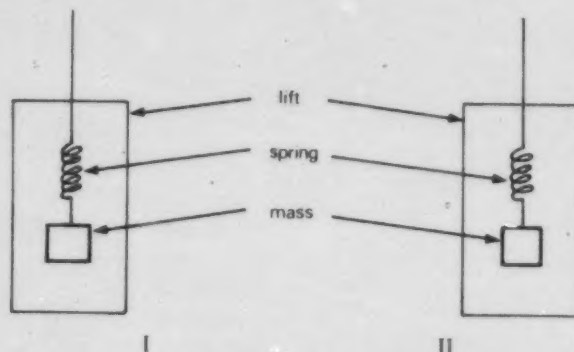
- 1 What is the net force available to accelerate the body to the right?
A 1 N C 4 N
B 2 N D 5 N
- 2 What is the magnitude of the net force acting on the body?
A 1 N C 4 N
B 2 N D 5 N

Questions 3–6 refer to the following information:
Two pairs of situations are described. For each pair of situations, different quantities are to be compared. Use the following key to indicate the comparison relevant to each question.

KEY

- A The quantity in situation I is *greater* than that in situation II.
- B The quantity in situation I is *equal* to that in situation II.
- C The quantity in situation I is *less* than that in situation II.
- D There is insufficient information to determine the relation between the two situations for the given quantity.

Questions 3 & 4 refer to the following two situations:



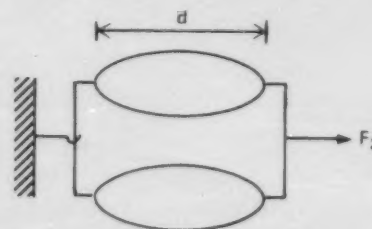
A mass is hanging from a spring in a stationary lift. The lift is now travelling upwards with an increasing velocity.

- 3 What is the relationship between the *tension* in the spring in the two situations?
- 4 What is the relationship between the *force of gravity* on the mass in the two situations?

Question 5 refers to the following two situations:



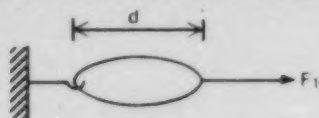
Two identical rubber bands are connected as shown and each is extended to a length d by a force.



The same two rubber bands are now connected in parallel. Each is again extended to a length d by a force.

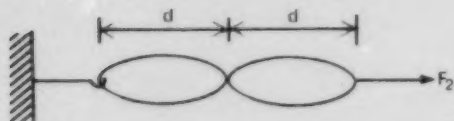
- 5 What is the relationship between the *force applied* to the rubber bands in each situation?

Question 6 refers to the following two situations:



I

A rubber band, attached to a hook in a wall is extended to a length d by a force.



II

A second identical rubber band is connected to the original one and each is extended to a length d by a force.

- 6 What is the relationship between the force applied to the rubber bands in each situation?
- 7 According to Newton's Third Law, 'to every action there is an equal and opposite reaction'. Suppose that a box is at rest on a rough horizontal floor. If the weight of the box is regarded as the 'action', the 'reaction' is
- A the upward force of the floor on the box.
 B the downward force of the box on the floor.
 C the gravitational attraction of the box pulling upward on the earth.
 D zero in this case, because the box is at rest.

Questions 8-10 refer to the following information:

A frictionless box of mass m kilogram is at rest on a smooth horizontal table. A horizontal force of F newton is applied. The gravitation field strength is g newton per kilogram.

- 8 What is the magnitude of the horizontal acceleration of the box?
- A $\frac{F}{m}$ C $\frac{F}{g}$
 B g D $\frac{F}{mg}$
- 9 What is the weight of the box?
- A F C Fmg
 B $\frac{F^2}{m}$ D mg
- 10 What is the magnitude of the vertical force of the table on the box?
- A mg C F
 B $\frac{F^2}{m}$ D Fmg

Questions 11 & 12 refer to the following information:

A force of 12 newton is applied to two packing cases of masses 4 kilogram and 2 kilogram on a frictionless horizontal surface as shown in the diagram.



- 11 What is the magnitude of the force exerted by the 4 kilogram packing case on the 2 kilogram case?
- A 12 C 2
 B 4 D unable to be determined due to insufficient information.
- 12 What is the magnitude of the force exerted by the 2 kilogram packing case on the 4 kilogram case?
- A 12 C 2
 B 4 D unable to be determined due to insufficient information.

Questions 13-16 refer to the following information:

An astronaut on the moon lets a spanner and a feather fall simultaneously and they hit the moon's surface together. On Earth, the spanner would have hit the ground first.

- 13 The spanner and feather arrived at the moon's surface together because
- A on the earth, the gravitational force on the spanner is not equal to the gravitational force on the feather, whereas on the moon, they are equal.
 B gravitational force laws on the earth do not apply on the moon.
 C the acceleration due to gravity on the earth is much greater than the acceleration due to gravity on the moon.
 D the earth has an atmosphere, whereas the moon does not have an atmosphere.
- 14 The rule that the ratio
- $$\frac{\text{gravitational force on spanner}}{\text{inertial mass of spanner}}$$
- is equal to the ratio
- $$\frac{\text{gravitational force on feather}}{\text{inertial mass of feather}}$$
- applies
- A on the moon only.
 B on the earth only.
 C on the moon and the earth.
 D neither on the moon nor the earth.

15 The ratio $\frac{\text{gravitational force on spanner}}{\text{gravitational force on feather}}$ is

- A much greater on the earth than it is on the moon.
- B much less on the earth than it is on the moon.
- C the same on the earth as it is on the moon and equal to one.
- D the same on the earth as it is on the moon, but greater than one.

Question 16 refers to the following additional information:

The acceleration of the spanner on the earth would be six times as great as it is on the moon.

16 The ratio $\frac{\text{inertial mass of spanner on Earth}}{\text{inertial mass of spanner on moon}}$ is equal to

- A $\frac{1}{6}$
- B 1.
- C 6.
- D 36.

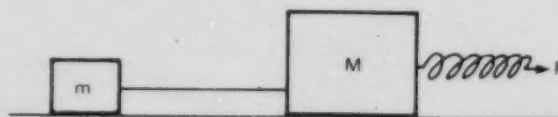
- 17 A boy *Q* sits on a sledge while boys *P* and *R* pull it as shown in the diagram. When *P* exerts a constant horizontal force of magnitude 400 newtons and *R* exerts a constant horizontal force of magnitude 200 newtons the sledge has an acceleration of 5.0 m s^{-2} .



What is the magnitude of the acceleration of the sledge if *R* lets go and *P* only is pulling the sledge?

- A 5 m s^{-2}
- B 7.5 m s^{-2}
- C 10 m s^{-2}
- D 15 m s^{-2}

Questions 18–22 refer to the following information:



Two boxes of different mass rest on a smooth surface and are joined by a piece of inelastic string. A spring then exerts a force of *F* newton on the larger mass, as shown in the diagram.

- 18 The acceleration of the larger mass is

- A $\frac{F}{M + m}$
- B $\frac{F}{M}$
- C $\frac{F}{m}$
- D neither A nor B nor C, there is insufficient information provided.

- 19 The acceleration of the smaller mass is

- A less than the acceleration of the larger mass.
- B equal to the acceleration of the larger mass.
- C greater than the acceleration of the larger mass.

- 20 The tension in the string which joins the two masses is equal to

- A *F*.
- B $\frac{M + mF}{M}$
- C $\frac{MF}{M + m}$
- D $\frac{mF}{M + m}$

- 21 The forward force applied by the string on *m* is

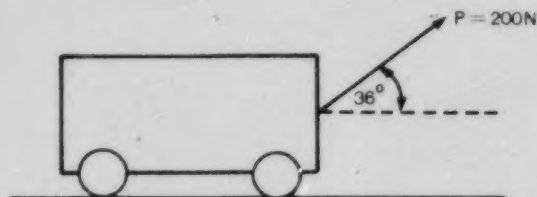
- A equal and opposite to the backward force applied by the string on *M*.
- B equal and in the same direction to the backward force applied by the string on *M*.
- C less than the backward force applied by the string on *M*.
- D greater than the backward force applied by the string on *M*.

- 22 Which one of the following is the net force on *m*?

- A $\frac{Fm}{m + M}$
- B $\frac{FM}{m + M}$
- C $\frac{Fm}{M}$
- D *F*

Questions 23–25 refer to the following information:

A boy exerts a force of 200 newton on the handle of a trolley. The handle makes an angle of 36° with the horizontal, as shown in the diagram.



For questions 23–25, use the following values where appropriate.

$$\sin 36^\circ = 0.6$$

$$\cos 36^\circ = 0.8$$

$$\tan 36^\circ = 0.7$$

$$g = 10 \text{ N kg}^{-1}$$

23 What is the horizontal component of the force?

- A 120 N C 160 N
B 140 N D 200 N

24 If the mass of the trolley is 50 kilogram, what is its weight?

- A 4 N C 50 N
B 40 N D 500 N

25 What is the upward force of the ground on the trolley?

- A 170 N C 380 N
B 340 N D 620 N

Question 26 refers to the following information:

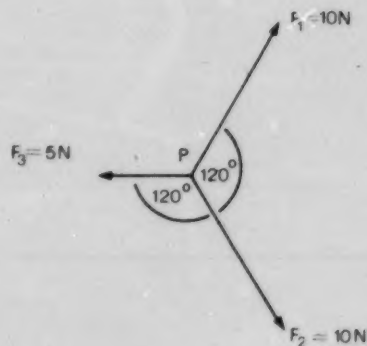
Use the following values where appropriate.

$$\cos 30^\circ = \frac{\sqrt{3}}{2}$$

$$\cos 60^\circ = \frac{1}{2}$$

$$\sin 30^\circ = \frac{1}{2}$$

$$\sin 60^\circ = \frac{\sqrt{3}}{2}$$



26 In the above diagram, three forces F_1 , F_2 and F_3 are acting on the body at P. What is the net force?

- A zero
B 5 N in the direction of F_3
C 5 N in the opposite direction to F_3
D 15 N in the opposite direction to F_3

Questions 27-29 refer to the following information:
A student uses carts, bricks, rubber loops and a ticker-timer to investigate the relations between force (F), mass (m) and acceleration (a). He obtains the following graphs as a result of his investigations.

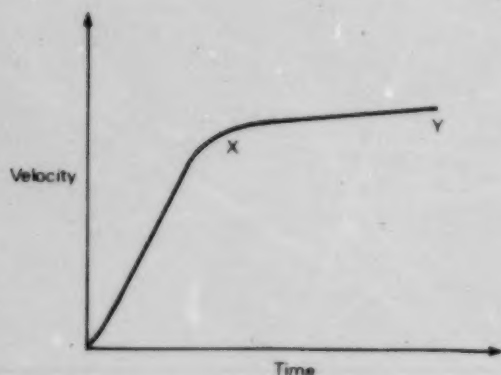


Figure 1: Cart only given an initial push.

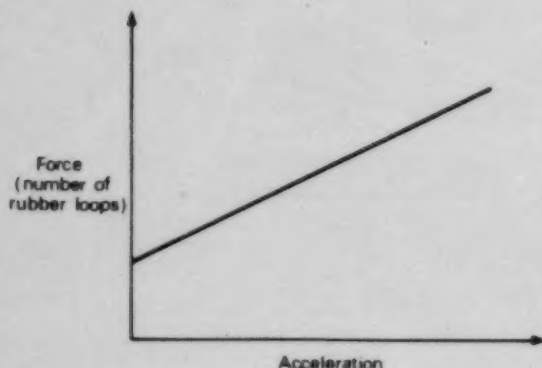


Figure 2: Various forces applied to the cart.

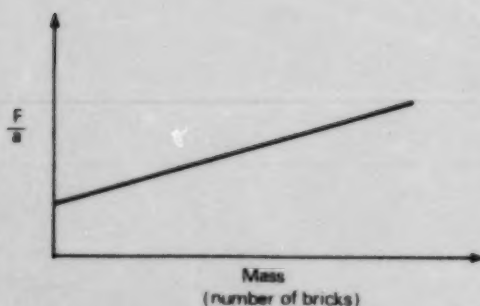


Figure 3: Different numbers of bricks added to cart.

The following key gives five explanatory statements related to the above experiments.

KEY

- I Various frictional forces were acting.
- II The cart itself possesses mass.
- III Experimental errors in measurement.
- IV The bricks were of unequal mass.
- V The table on which the experiments were performed was sloping, so that the cart was running downhill.

27 Which statement best explains the slightly rising section XY of Figure 1?

- | | |
|------|-------|
| A I | C III |
| B II | D V |

28 Which statement best explains why Figure 2 does not pass through the origin?

- | | |
|------|-------|
| A I | C III |
| B II | D V |

29 Which statement best explains why Figure 3 does not pass through the origin?

- | | |
|------|-------|
| A I | C III |
| B II | D IV |

ACER PHYSICS UNIT TESTS

The ACER Physics Tests consist of the following publications.

I A series of tests covering the following topics

- 1 *Physical measurement*
- 2 *Vectors*
- 3 *Motion in one dimension*
- 4 *Motion on a plane*
- 5 *Dynamics*
- 6 *Work and energy*
- 7 *Linear momentum*
- 8 *Oscillations*
- 9 *Gravity and Kepler's laws*
- 10 *Waves*
- 11 *Light — reflection and refraction*
- 12 *Light — interference, diffraction and spectra*
- 13 *Models of light*
- 14 *Kinetic theory of gases*
- 15 *Static charges*
- 16 *Electric field and potential difference*
- 17 *Current electricity*
- 18 *The magnetic field*
- 19 *Induced EMF*
- 20 *Atomic physics*
- 21 *Quantum physics*

II Teachers Information Booklet

III List of Answers Booklet

ACER Physics Unit Tests

Test 6 Work and energy

Directions

This test is designed to help you discover any difficulties and misunderstandings you may have in the work that you recently studied in your physics course. It is not intended to allocate a grade or mark to you as a result of taking the test. After completing and marking the test you will be able to make your own record of the questions that you were unable to answer correctly. This record will indicate the parts of the course to which you need to give further attention immediately.

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$$\sin 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\sin 60^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 30^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\cos 60^\circ = \frac{1}{2} = 0.50.$$

$$\tan 30^\circ = \frac{1}{\sqrt{3}} = 0.58.$$

$$\tan 45^\circ = 1$$

$$\tan 60^\circ = \sqrt{3} = 1.73$$

3. Unless otherwise instructed, neglect air resistance.

Jottings and calculations should be done on a separate sheet of paper.

Do not write on this test booklet
NOW TURN THE PAGE AND GO ON WITH THE TEST

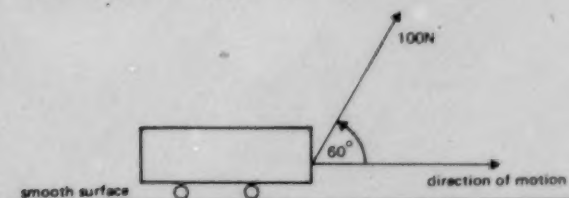
- 1 An 800 kg car changes speed from 20 m s^{-1} to 15 m s^{-1} . What is the decrease in the car's kinetic energy?

A $1.0 \times 10^4 \text{ J}$ C $7.0 \times 10^4 \text{ J}$
 B $5.0 \times 10^4 \text{ J}$ D $9.0 \times 10^4 \text{ J}$

- 2 A car of mass 800 kg starts from rest and accelerates uniformly to a speed of 15 m s^{-1} in 5.0 seconds. What is the average power generated in reaching this speed?

(Ignore power losses in overcoming friction.)
 A $1.8 \times 10^4 \text{ W}$ C $6.0 \times 10^4 \text{ W}$
 B $3.6 \times 10^4 \text{ W}$ D $7.2 \times 10^4 \text{ W}$

- 3 A trolley is moving horizontally along a smooth surface under the influence of a force of 100 N acting at an angle of 60° to the direction of motion.



The force acts for two seconds and, during the interaction, 200 J of energy are transferred to the trolley. The distance moved by the trolley during this time is

A 2.0 m. C 6.0 m.
 B 4.0 m. D 8.0 m.

- 4 A pellet having 5 J of kinetic energy is brought to rest after penetrating 0.1 m into a block of clay. Assuming the clay offers uniform resistance to the pellet until it is brought to rest, what is the value of this resistance?

A 0.02 N C $2 \times 10^1 \text{ N}$
 B 0.5 N D $5 \times 10^1 \text{ N}$

- 5 A block moves from rest down a frictionless inclined plane. Which one of the following statements best describes the energy changes?

A Gravitational potential energy is lost and the block gains an equivalent amount of kinetic energy.
 B The gravitational potential energy lost is transformed into kinetic energy and heat energy.
 C The change in energy equals the gain in kinetic energy plus the loss in potential energy.
 D The change in energy equals the gain in kinetic energy minus the loss in potential energy.

Questions 6-8 refer to the following information:

Two cars, M and N, have identical masses. M is travelling at twice the velocity of N in the same direction.

- 6 What is the value of the ratio

$$\frac{\text{kinetic energy of } M}{\text{kinetic energy of } N}?$$

A $\frac{1}{4}$ C $\frac{2}{1}$
 B $\frac{1}{2}$ D $\frac{4}{1}$

- 7 The drivers of both cars apply the brakes and come to a stop in the same distance.

What is the value of the ratio

$$\frac{\text{average force applied by road to stop } M}{\text{average force applied by road to stop } N}?$$

A $\frac{1}{4}$ C $\frac{2}{1}$
 B $\frac{1}{2}$ D $\frac{4}{1}$

- 8 When the cars stop, most of their energy is dissipated as heat in the brake linings.

What is the approximate value of the ratio

$$\frac{\text{heat dissipated in brake linings of } M}{\text{heat dissipated in brake linings of } N}?$$

A $\frac{1}{4}$ C $\frac{2}{1}$
 B $\frac{1}{2}$ D $\frac{4}{1}$

Questions 9-11 refer to the following information:

A boy of mass 40.0 kg falls from rest a distance of 2.0 m on to a trampoline.

- 9 What is the kinetic energy of the boy as he lands on the trampoline?

A $8.0 \times 10^2 \text{ J}$ C $8.0 \times 10^1 \text{ J}$
 B $4.0 \times 10^2 \text{ J}$ D $4.0 \times 10^1 \text{ J}$

- 10 When the boy is brought momentarily to rest, he has depressed the trampoline surface by 0.20 m. What is the average force exerted on the boy by the trampoline?

A $4.0 \times 10^3 \text{ N}$ C $4.0 \times 10^2 \text{ N}$
 B $2.0 \times 10^3 \text{ N}$ D $2.0 \times 10^2 \text{ N}$

- 11 The boy is projected upwards again and leaves the trampoline with 95% of his kinetic energy at impact. How high above the trampoline will he rise?

A 2.0 m C 1.8 m
 B 1.9 m D 1.7 m

- 12 A man pushes on a wall with a force of 100 N for 10 seconds without moving the wall. The work done by the man on the wall is
 A 0 J. C 100 J.
 B 10 J. D 1000 J.

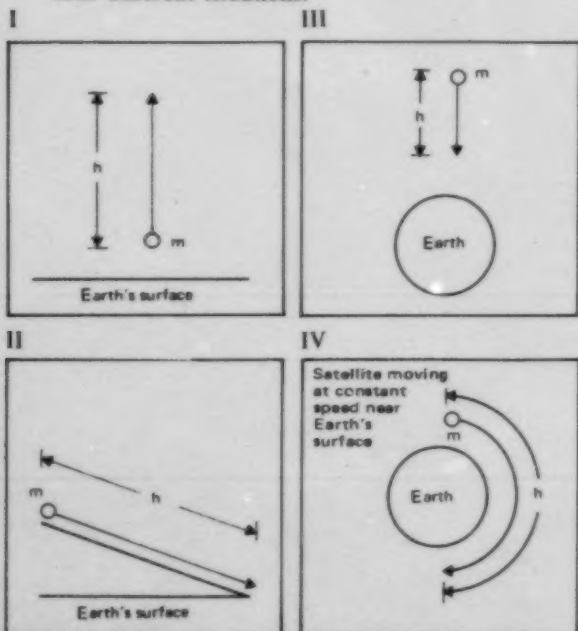
Questions 13-15 refer to the following information:

A sphere of mass 5.0 kg is placed on top of a compressed spring, as shown in the diagram.



The compressed spring is able to store 150 J of energy. When released, the spring transfers all its stored energy to the sphere. Ignore air resistance.

- 13 The spring is released. What is the maximum velocity attained by the sphere immediately after the sphere leaves the spring?
 A 5.5 m s^{-1} C 30 m s^{-1}
 B 7.7 m s^{-1} D 60 m s^{-1}
- 14 What would be the maximum height reached by the sphere above its point of release?
 A 0.80 m C 3.0 m
 B 1.5 m D 6.0 m
- 15 What would be the speed of the sphere 1.5 m above the point of release?
 A 30 m s^{-1} C 6.7 m s^{-1}
 B 15 m s^{-1} D 5.5 m s^{-1}
- 16 The diagrams I to IV, not drawn to scale, represent a mass m moving from one position to another in four different situations.



In which situation is the change in potential energy (ΔPE) equal to mgh , where h is shown on the diagram and g is the acceleration of gravity at the surface of the earth?

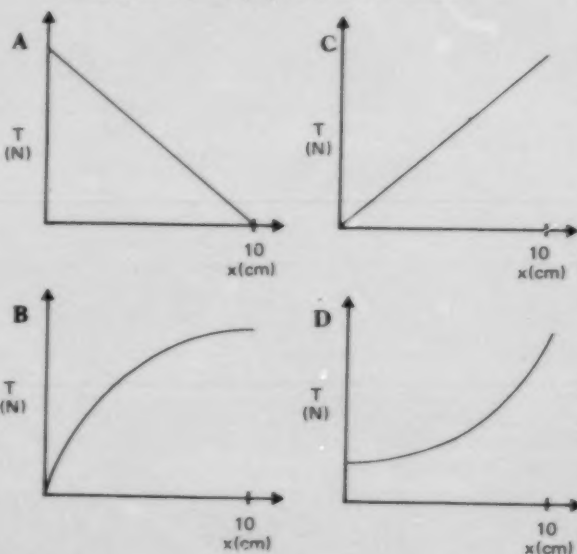
- A I C III
 B II D IV

Questions 17-20 refer to the following information:

A rope is tied to a mass of 8.0 kg which is at the bottom of a 10 m cliff. A man pulls the mass up to the top of the cliff at a constant speed of 2.0 m s^{-1} .

- 17 How much work does the man do?
 A $8.0 \times 10^1 \text{ J}$ C $8.0 \times 10^2 \text{ J}$
 B $4.0 \times 10^2 \text{ J}$ D $1.6 \times 10^3 \text{ J}$
- 18 At what average power does the man work?
 A $4.0 \times 10^1 \text{ W}$ C $4.0 \times 10^2 \text{ W}$
 B $1.6 \times 10^2 \text{ W}$ D $1.6 \times 10^3 \text{ W}$
- The following additional information is required for questions 19 and 20.
 The man now pulls the same mass up to the top of the cliff at a constant speed of 6.0 m s^{-1} .
- 19 How much work does the man now do?
 A $8.0 \times 10^1 \text{ J}$ C $8.0 \times 10^2 \text{ J}$
 B $1.3 \times 10^2 \text{ J}$ D $4.8 \times 10^3 \text{ J}$
- 20 At what average power does the man now work?
 A $1.6 \times 10^2 \text{ W}$ C $1.3 \times 10^3 \text{ W}$
 B $4.8 \times 10^2 \text{ W}$ D $1.6 \times 10^3 \text{ W}$
- 21 A perfectly elastic two-metre spring is attached to a wall. A man pulls on the spring and extends it by 10 centimetres.

Which one of the following graphs represent the relationship between the tension (T) in the spring and the extension (X) in this situation?

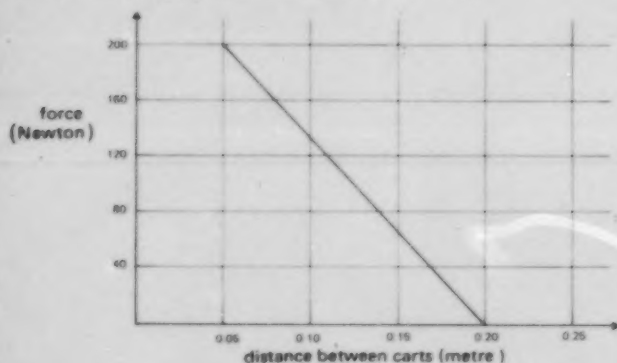


Questions 22–25 refer to the following information:

A cart, I, with a spring bumper attached to it, was moving at constant velocity V along a smooth, horizontal surface. It then collided with a stationary cart, II. The mass of each cart was 1.0 kg.



The graph shows how the force exerted by the spring on the carts varies with the distance between the carts (X), as cart I approached cart II.



22 What is the minimum separation of the carts?

- A 0.05 m C 0.15 m
B 0.10 m D 0.20 m

23 What is the work done by the spring on the two carts while they move from minimum separation to no longer being in contact?

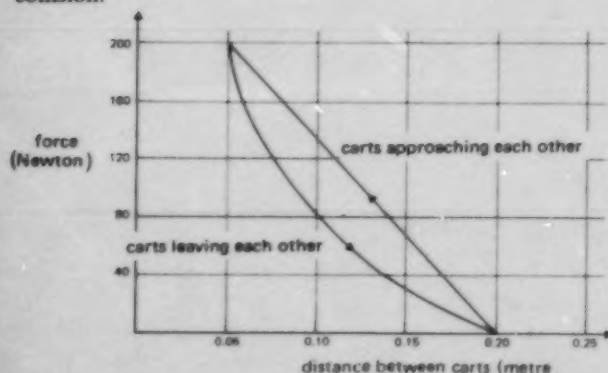
- A 5 J C 15 J
B 10 J D 20 J

24 What is the maximum value of the potential energy stored in the spring?

- A 10 J C 20 J
B 15 J D 25 J

The following additional information is required for question 25.

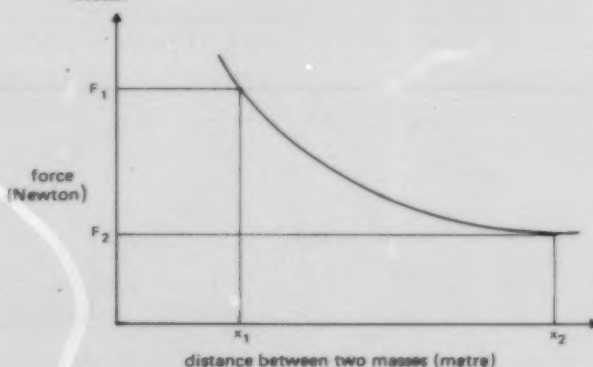
The graph shows the relation between force and distance between carts as the carts leave each other after collision.



25 This graph shows that the collision is

- A *elastic* since the force became zero at $x = 0.20$ m as the carts separated again.
B *elastic* as the maximum value of the force, F , is the same whether the carts were approaching or receding.
C *inelastic* because the force is zero for x greater than 0.20 m.
D *inelastic* because the value of F for a particular separation is not the same when the carts are receding as it was when they approached.

26 The graph shows how the force of attraction between two masses varies with the distance between them.



Which one of the following is the correct technique for calculating the amount of work required to increase the separation from x_1 to x_2 ?

- A Read off the values F_1 and F_2 , and then calculate $F_1 x_1 + F_2 x_2$.
B Read off the values F_1 and F_2 , and then calculate $F_2 x_2 - F_1 x_1$.
C Calculate the gradients at x_1 and x_2 and find their difference.
D Find the area under the curve between x_1 and x_2 .

Questions 27–29 refer to the following information:

An astronaut carries a hammer on the moon. The hammer has a mass of 0.72 kg on Earth. On the moon, the acceleration of gravity is one sixth of its value on Earth. (On Earth, $g = 10 \text{ m s}^{-2}$.)

27 What is the mass in kilograms of the hammer on the moon?

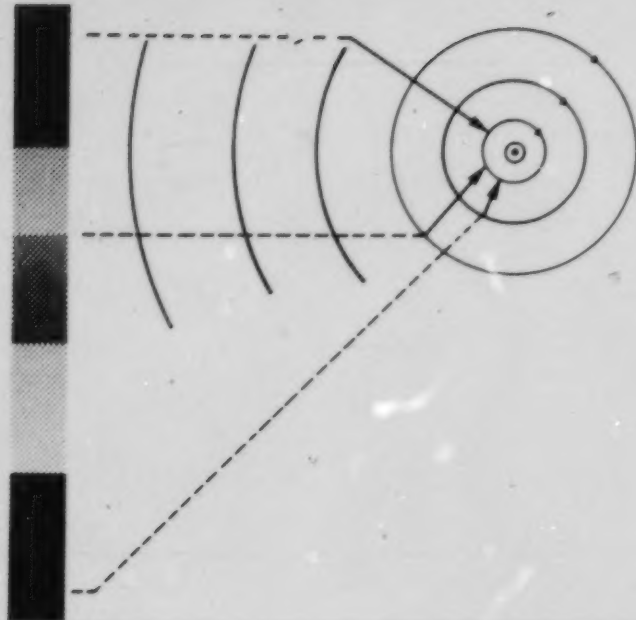
- A 0.12 C 1.2
B 0.72 D 7.2

28 What is the weight in newtons of the hammer on the moon?

- A 0.12 C 1.2
B 0.72 D 7.2

29 How much work must be done to raise the hammer through a vertical distance of 2.0 m on the moon?

- A 1.2 J C 7.2 J
B 2.4 J D $1.4 \times 10^1 \text{ J}$



Test 7 Linear momentum

Directions

This test is designed to help you discover any difficulties and misunderstandings you may have in the work that you recently studied in your physics course. It is not intended to allocate a grade or mark to you as a result of taking the test. After completing and marking the test you will be able to make your own record of the questions that you were unable to answer correctly. This record will indicate the parts of the course to which you need to give further attention immediately.

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- 2 For each question, several alternatives are given. You should choose the **best** answer from these alternatives.

The following information may be useful and should always be accepted where relevant.

- 1 Take the acceleration due to gravity, g as 10 m s^{-2} .
- 2 Where required by the calculations, take

$$\sin 30^\circ = \frac{1}{2} = 0.50.$$

$$\sin 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\sin 60^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 30^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\cos 60^\circ = \frac{1}{2} = 0.50.$$

$$\tan 30^\circ = \frac{1}{\sqrt{3}} = 0.58.$$

$$\tan 45^\circ = 1$$

$$\tan 60^\circ = \sqrt{3} = 1.73$$

- 3 Unless otherwise instructed, neglect air resistance.

Jottings and calculations should be done on a separate sheet of paper.

Do not write on this test booklet
NOW TURN THE PAGE AND GO ON WITH THE TEST

Questions 1 & 2 refer to the following information:

A force of 2N uniformly accelerates a mass of 4 kg for 0.4 s.

- 1 The change in momentum of the object in the direction of the force is
 A 8 kg m s^{-1} C 2 kg m s^{-1}
 B 3 kg m s^{-1} D 0.8 kg m s^{-1}
- 2 The magnitude of the change in velocity is approximately
 A 3 m s^{-1} C 0.5 m s^{-1}
 B 2.0 m s^{-1} D 0.2 m s^{-1}

Questions 3 & 4 refer to the following information:

An air rifle pellet of mass one gram and velocity 100 metres per second penetrates five centimetres into a lump of clay and comes to rest in one millisecond. Assume that the force acting on the pellet when in the clay is constant.

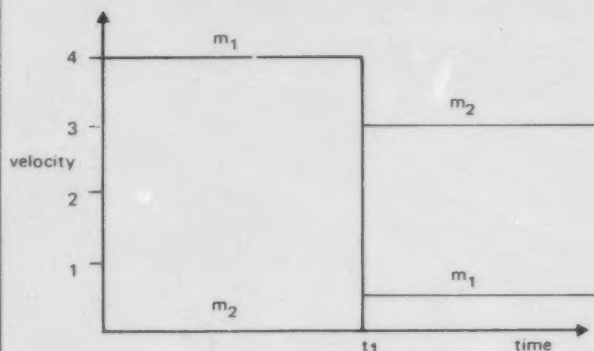
- 3 The magnitude of the change in momentum of the pellet is
 A 5 kg m s^{-1} C $1 \times 10^{-1} \text{ kg m s}^{-1}$
 B $2 \times 10^{-1} \text{ kg m s}^{-1}$ D $5 \times 10^{-5} \text{ kg m s}^{-1}$
- 4 The magnitude of the force acting on the pellet is
 A $1 \times 10^2 \text{ N}$ C $2 \times 10^{-2} \text{ N}$
 B $5 \times 10^{-1} \text{ N}$ D $5 \times 10^{-2} \text{ N}$
- 5 A golf ball is hit with a force of 8000 N and the ball and the club are in contact for 1 millisecond. In order to calculate the change in momentum using this information, it is also necessary to know
 A only the mass of the ball.
 B both the mass of the ball and the club.
 C only the distance the ball travelled.
 D neither A nor B nor C, as no additional information is required.
- 6 A ball of mass 0.5 kg strikes an irregular surface at an angle of 20° , and rebounds at an angle of 70° , as shown in the diagram. Its initial and final speeds are 8 m s^{-1} and 6 m s^{-1} respectively.



What is the magnitude of the change in momentum of the ball?

- A 1 kg m s^{-1} C 7 kg m s^{-1}
 B 5 kg m s^{-1} D 10 kg m s^{-1}

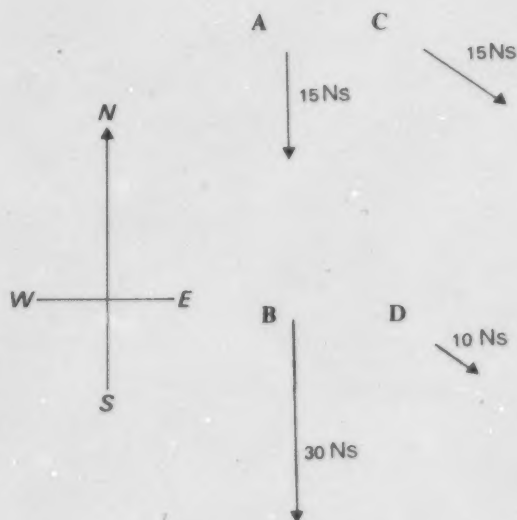
- 7 The diagram is a velocity-time graph for two objects whose masses are m_1 and m_2 . The objects collide head on at time t_1 . Assume that the net force on the system is zero.



Which one of the following describes the relationship between the masses?

- A $m_1 = m_2$
 B $m_1 > m_2$
 C $m_1 < m_2$
 D unable to be determined from the information given

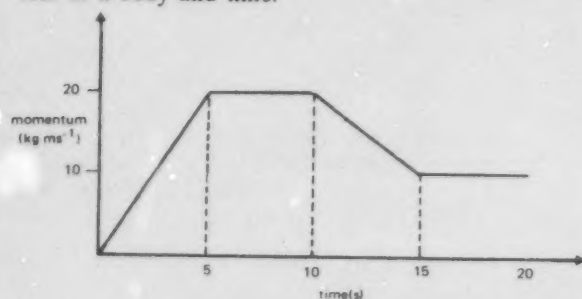
- 8 A body of mass 2.0 kg moving south east had a force of 5.0 N south acting on it for 3.0 s. Which vector best represents the impulse exerted on the body by the force?



- 9 A boy travelling on a skateboard steps off the board perpendicular to its motion. After stepping off, the boy lands on the ground and comes to rest. Which one of the following statements is **incorrect**?
- A The boy exerts an impulse on the ground on impact.
 - B The ground exerts an impulse on the boy on impact.
 - C The momentum possessed by the boy before the collision is shared with the earth.
 - D The momentum possessed by the boy before the collision is transformed to heat.

- 10 A girl travels on a skateboard at 5.0 m s^{-1} , and steps off in such a way that her speed relative to the ground will be less than 5.0 m s^{-1} when she leaves the skateboard. Assume speeds are in the same direction. The subsequent speed of the skateboard will
- A be less than 5.0 m s^{-1} .
 - B remain at 5.0 m s^{-1} .
 - C increase equal to the amount the girl reduces her speed in stepping off.
 - D increase by an amount but this cannot be calculated from the information given.

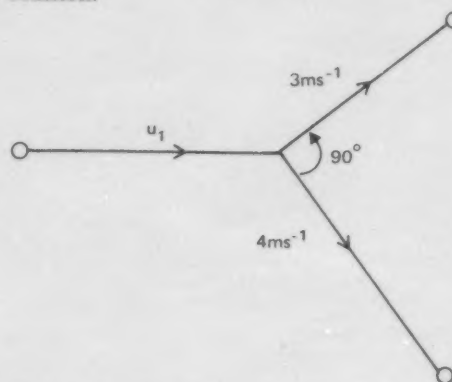
Questions 11–14 refer to the following information:
The graph shows the relationship between the momentum of a body and time.



- 11 What is the magnitude of the impulse exerted on the body over the first five seconds?
- A 4 kg m s^{-1}
 - B 20 kg m s^{-1}
 - C 50 kg m s^{-1}
 - D 100 kg m s^{-1}
- 12 What is the magnitude of the resultant force acting on the body for the first five seconds?
- A 4 N
 - B 20 N
 - C 50 N
 - D 100 N
- 13 The gradient of the graph gives a measure of
- A the resultant force acting on the body.
 - B the mass of the body.
 - C the kinetic energy of the body.
 - D the velocity of the body.

- 14 Which one of the following statements gives the best description of the motion of the body for the 20-second period shown?
- A The body accelerates throughout the 20-second period.
 - B The body accelerates between 0–5 seconds and 10–15 seconds and has constant speed at other times.
 - C The body moves in one direction from 0–5 seconds, comes to rest, moves in the opposite direction from 10–15 seconds, then is stationary again.
 - D The body speeds up from 0–10 seconds, then slows down from 10–20 seconds.

Questions 15 & 16 refer to the following information:
A sphere of mass 0.1 kg , moving with speed u_1 , collides elastically with a stationary sphere of the same mass. The diagram represents the velocities of the balls after the collision.



- 15 The magnitude of the momentum of the system before the collision was
- A 2 kg m s^{-1}
 - B 1 kg m s^{-1}
 - C 0.7 kg m s^{-1}
 - D 0.5 kg m s^{-1}
- 16 The initial speed u_1 was
- A 7 m s^{-1}
 - B 5 m s^{-1}
 - C 4 m s^{-1}
 - D 3 m s^{-1}

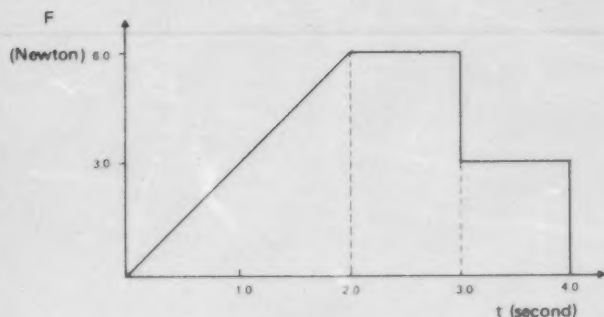
Questions 17 & 18 refer to the following information:

A cart of mass 1.5 kg and moving at a speed of 5.0 m s^{-1} collides head on with a stationary cart of mass 4.0 kg . The 1.5 kg cart rebounds with a speed of 3.0 m s^{-1} . Assume momentum is conserved.

- 17 The speed of the 4 kg cart after the collision would be
- A zero.
 - B 1.9 m s^{-1}
 - C 3.0 m s^{-1}
 - D 5.0 m s^{-1}
- 18 If the collision took place in 0.01 seconds, the average force acting between the carts would have been
- A $1.2 \times 10^3 \text{ N}$
 - B $5.5 \times 10^2 \text{ N}$
 - C 0.50 N
 - D zero.

Questions 19-22 refer to the following information:

A body of mass 2.0 kg is moving due west at 1.5 m s^{-1} when a force, the direction of which is also to the west, acts upon it for 4 s . The diagram shows a graph of the variation of the force with time.



19 What is the magnitude of the impulse exerted on the body in the first two seconds for which the force acts?

- A 3 kg m s^{-1} C 9 kg m s^{-1}
B 6 kg m s^{-1} D 12 kg m s^{-1}

20 What is the magnitude of the total impulse exerted on the body by the force?

- A 12 kg m s^{-1} C 21 kg m s^{-1}
B 15 kg m s^{-1} D 24 kg m s^{-1}

21 What is the magnitude of the final velocity of the body?

- A 7.5 m s^{-1} C 12 m s^{-1}
B 9 m s^{-1} D 13.5 m s^{-1}

Question 22 refers to the following additional information:

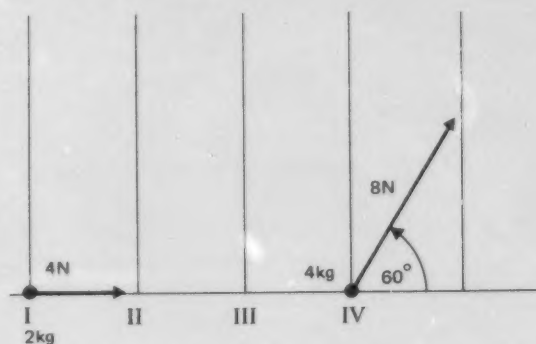
The force now acts in the opposite direction (i.e. to the east) while all other conditions remain constant.

22 For which of the following quantities would the magnitude have been different?

- A the impulse exerted on the body in the first two seconds
B the total impulse exerted on the body
C the final velocity of the body
D all of A, B, and C

Questions 23-25 refer to the following information:

Two masses are subjected to different forces as indicated in the diagram.



23 Which one of the positions indicates the centre of mass of the system?

- A I C III
B II D IV

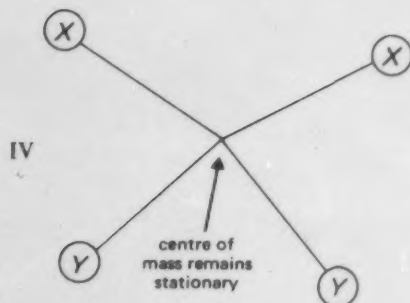
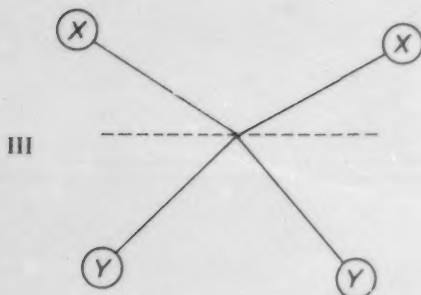
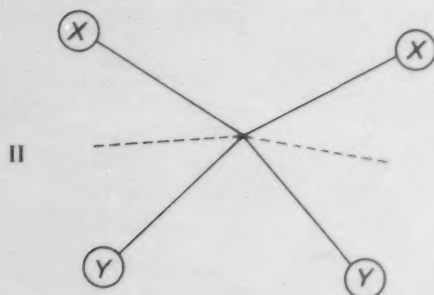
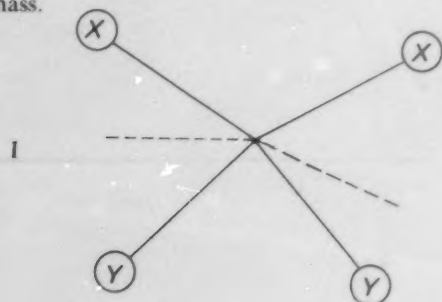
24 The apparent net force acting on the centre of mass of the system is

- A 12 N . C 8 N .
B $4\sqrt{7} \text{ N}$. D $4\sqrt{3} \text{ N}$.

25 The magnitude of the acceleration of the centre of mass is

- A $\frac{2}{3}\sqrt{3} \text{ m s}^{-2}$. C $\frac{2}{3}\sqrt{7} \text{ m s}^{-2}$.
B $1\frac{1}{3} \text{ m s}^{-2}$. D 2 m s^{-2} .

- 26 Diagrams I–IV represent the collision of two balls X and Y. Both balls are moving with the same speed and ball X has a mass twice that of ball Y. Dotted lines represent the motion of the centre of mass.



Which one of the diagrams most closely represents the motion of the centre of mass of the two balls?

- A I
B II
C III
D IV

Questions 27 & 28 refer to the following information:

A system consists of three particles: the first of mass 4.0 kg travelling east at 7.0 m s^{-1} , the second of mass 2.0 kg travelling north at 5.0 m s^{-1} , and the third of mass 1.0 kg travelling west at 4.0 m s^{-1} .

- 27 What is the magnitude of the momentum of the system?

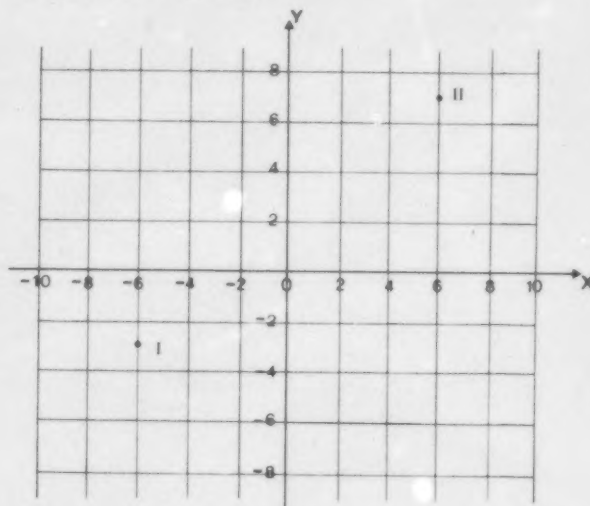
- A $2.6 \times 10^1 \text{ kg m s}^{-1}$ C $4.2 \times 10^1 \text{ kg m s}^{-1}$
B $4.1 \times 10^1 \text{ kg m s}^{-1}$ D $1.1 \times 10^2 \text{ kg m s}^{-1}$

- 28 What is the direction of the momentum vector for the system?

- A $\tan^{-1} \theta = \frac{5}{3} \text{ N of E}$ C $\tan^{-1} \theta = \frac{12}{5} \text{ N of E}$
B $\tan^{-1} \theta = \frac{3}{5} \text{ N of E}$ D $\tan^{-1} \theta = \frac{5}{12} \text{ N of E}$

Questions 29 & 30 refer to the following information:

A body was placed at rest at the origin of a grid drawn upon a horizontal surface. The body exploded into three fragments, I, II, and III, each of which had mass M . The positions in which two of these fragments were found, 0.1 second after the explosion, are represented on the grid. All three fragments moved horizontally with constant velocities.



- 29 What is the x co-ordinate of piece III 0.1 s after the explosion?

- A -4
B 0
C 4
D unable to be determined from the information given

- 30 What is the y co-ordinate of piece III 0.1 s after the explosion?

- A -4
B 0
C 4
D unable to be determined from the information given

ACER PHYSICS UNIT TESTS

The ACER Physics Tests consist of the following publications.

I A series of tests covering the following topics

- 1 Physical measurement*
- 2 Vectors*
- 3 Motion in one dimension*
- 4 Motion on a plane*
- 5 Dynamics*
- 6 Work and Energy*
- 7 Linear momentum*
- 8 Oscillations*
- 9 Gravity and Kepler's laws*
- 10 Waves*
- 11 Light — reflection and refraction*
- 12 Light — interference, diffraction and spectra*
- 13 Models of light*
- 14 Kinetic theory of gases*
- 15 Static charges*
- 16 Electric field and potential differences*
- 17 Current electricity*
- 18 The magnetic field*
- 19 Induced emf*
- 20 Atomic physics*
- 21 Quantum physics*

II Teachers Information Booklet

III List of Answers Booklet

Test 8 Oscillations

Directions

This test is designed to help you discover any difficulties and misunderstandings you may have in the work that you recently studied in your physics course. It is not intended to allocate a grade or mark to you as a result of taking the test. After completing and marking the test you will be able to make your own record of the questions that you were unable to answer correctly. This record will indicate the parts of the course to which you need to give further attention immediately.

When answering the questions keep these points in mind:

- 1 Do not spend too much time on any one question. If it seems too difficult omit it and go on to the next question.
- 2 For each question, several alternatives are given. You should choose the **best** answer from these alternatives.

The following information may be useful and should always be accepted where relevant.

- 1 Take the acceleration due to gravity, g as 10 m s^{-2} .
- 2 Where required by the calculations, take

$$\sin 30^\circ = \frac{1}{2} = 0.50.$$

$$\sin 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\sin 60^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 30^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\cos 60^\circ = \frac{1}{2} = 0.50.$$

$$\tan 30^\circ = \frac{1}{\sqrt{3}} = 0.58.$$

$$\tan 45^\circ = 1$$

$$\tan 60^\circ = \sqrt{3} = 1.73$$

- 3 Unless otherwise instructed, neglect air resistance.

Jottings and calculations should be done on a separate sheet of paper.

Do not write on this test booklet
NOW TURN THE PAGE AND GO ON WITH THE TEST

- 1 A simple pendulum with a bob of mass 50 g has a period T . What is the period, in terms of T , if this bob is replaced by one of mass 200 g?

A $\frac{T}{4}$ C $\frac{4}{T}$
 B T D $2T$

- 2 A light helical spring, when loaded with a mass of 50 g, has a period of oscillation T . What is the period, in terms of T , if this mass is replaced by one of mass 200 g?

A $\frac{T}{4}$ C $\frac{4}{T}$
 B T D $2T$

- 3 When a particle is undergoing simple harmonic motion (S.H.M.), its velocity is a maximum when its
 A displacement is a maximum.
 B kinetic energy is zero.
 C acceleration is zero.
 D potential energy is a maximum.

Questions 4-7 refer to the following information:

A mass of 0.10 kg is placed 0.15 m from the centre of a turntable rotating at a uniform rate.

Diagram 1 represents the turntable when viewed from above.

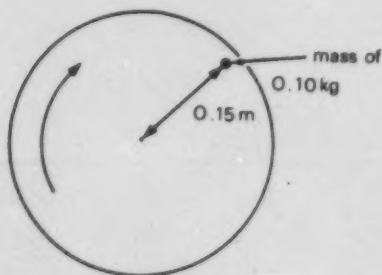


Diagram 1

An observer, viewing the turntable from the side, sees the mass to be moving in a straight line between two extreme points. These two points, P and T, and three other points at equal intervals, Q, R and S, are labelled in Diagram 11, not drawn to scale.

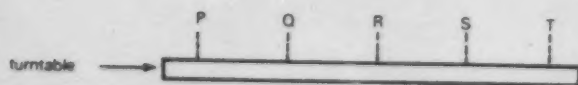


Diagram 11

- 4 What is the length PT ?

A 0.15 m.
 B greater than 0.15 m but less than 0.30 m.
 C 0.30 m.
 D greater than 0.30 m.

- 5 To the observer, the motion as seen from the side is

A uniformly accelerated motion.
 B motion with constant speed.
 C simple harmonic motion.
 D motion with constant speed, except at points P and T.

- 6 To the observer, the speed of the mass is greatest at

A point R. C points Q, R and S.
 B points P and T. D points P, Q, R, S and T, as it is constant.

- 7 To the observer, the magnitude of the acceleration is greatest at

A points P and T. C points Q, R and S.
 B point R. D no point, as it is always zero.

- 8 A particular pendulum has a period on Earth of 3 seconds. If the pendulum is set in motion on the moon, where the acceleration due to gravity, g_{moon} , is less than the acceleration due to gravity on Earth, g_{earth} , the period on the moon will be

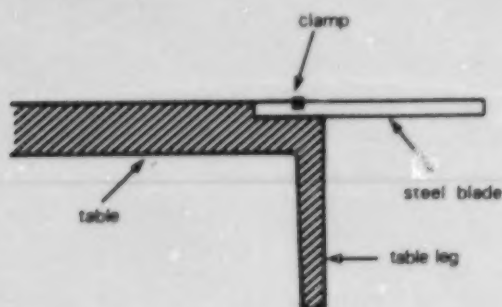
A greater than 3 seconds.
 B 3 seconds (i.e. the same).
 C less than 3 seconds.
 D unable to be determined, as the pendulum will not operate where there is no atmosphere to provide a restoring force.

- 9 Resonance occurs in a system if

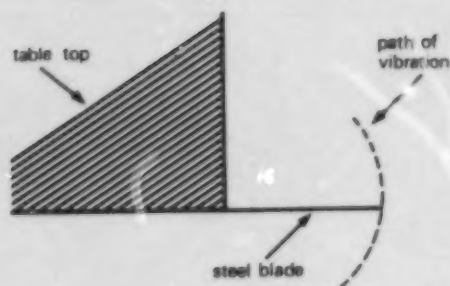
A the driving force has equal amplitude but is opposite in direction to the restoring force.
 B the amplitude of the natural (i.e. free) vibrations and the amplitude of the restoring force are the same.
 C the frequency of the driving force and the frequency of the free vibrations are the same.
 D the driving force is at its peak value.

Questions 10–15 refer to the following information:

A flat steel blade of negligible mass is fixed to a table so that it can vibrate in a horizontal plane as shown in the diagram.



SIDE VIEW



TOP VIEW

The deflection of the tip of the blade is proportional to the force applied at the tip. That is, the ratio $\frac{\text{applied force}}{\text{deflection caused}}$ is a constant, commonly called the force constant. A deflection of 0.04 m results from a force of 0.4 N.

A mass of 2.5 kg is attached to the tip of the steel blade. The steel blade is then pulled aside a distance of 5 cm and released.

10 What is the force constant of the steel blade?

- A 0.1 N m^{-1} C 2 N m^{-1}
B 0.5 N m^{-1} D 10 N m^{-1}

11 What is the period of vibration of the steel blade?

- A $\frac{\pi}{2} \text{ s}$ C $4\pi \text{ s}$
B $\pi \text{ s}$ D $8\pi \text{ s}$

12 How much potential energy is stored in the loaded blade when the deflection is 5 cm?

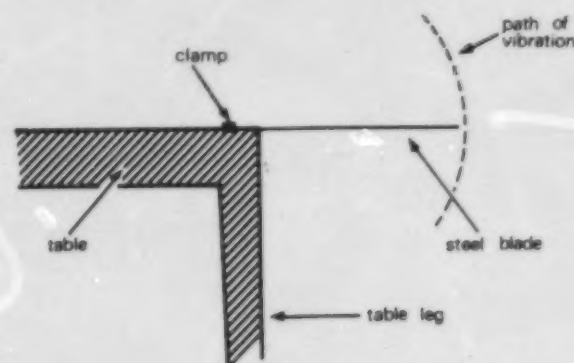
- A $1.25 \times 10^{-2} \text{ J}$ C 0.25 J
B $2.5 \times 10^{-2} \text{ J}$ D 0.50 J

13 What is the speed of the tip of the loaded blade when it is passing through the equilibrium position?

- A $5 \times 10^{-3} \text{ m s}^{-1}$ C 10^{-1} m s^{-1}
B $2 \times 10^{-2} \text{ m s}^{-1}$ D 10 m s^{-1}

Questions 14 & 15 refer to the following additional information:

The same blade is clamped to the table so that it can vibrate in a vertical plane.



SIDE VIEW

The 2.5 kg mass is replaced by a mass of 0.025 kg which is attached to the tip of the steel blade. This mass causes a deflection of the tip of the steel blade to a new equilibrium position.

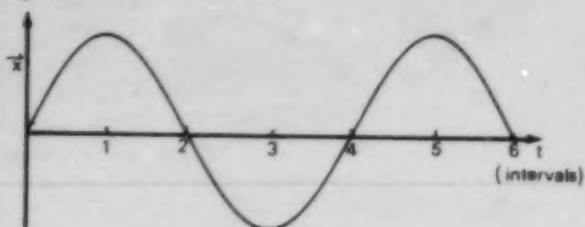
14 What is the magnitude of the deflection to the new equilibrium position?

- A 0.025 m C $\sqrt{0.025} \text{ m}$
B 0.05 m D $\sqrt{0.05} \text{ m}$

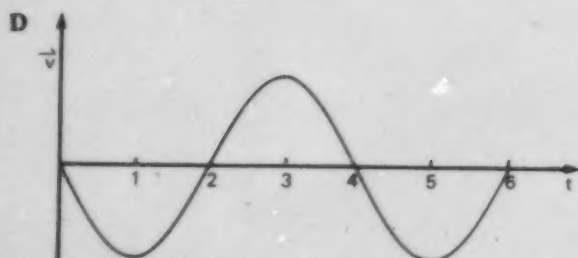
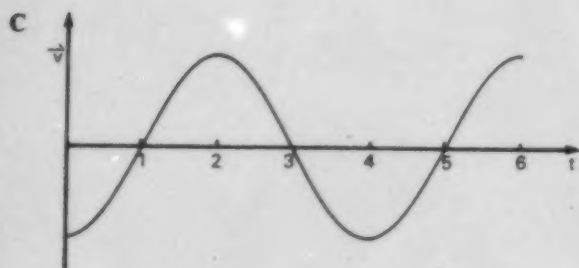
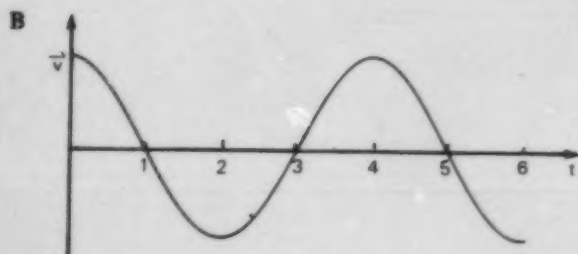
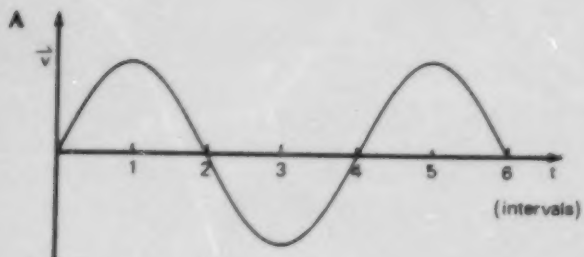
15 When the loaded blade is set into oscillation, what is its period of vibration?

- A $\frac{\pi}{20} \text{ s}$ C $40\pi \text{ s}$
B $\frac{\pi}{10} \text{ s}$ D unable to be determined from the information given.

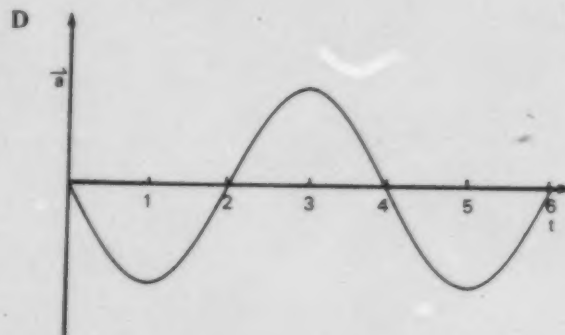
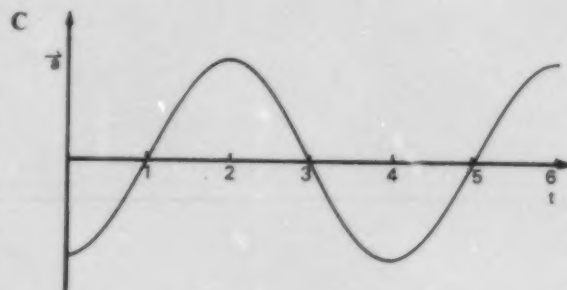
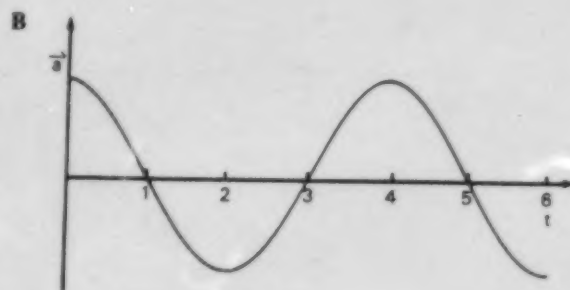
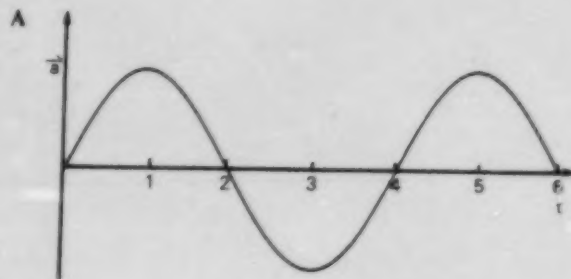
Questions 16 & 17 refer to the following information:
The graph depicts the relationships between the displacement, x , of a particle executing simple harmonic motion and elapsed time, t . The positive direction is up.



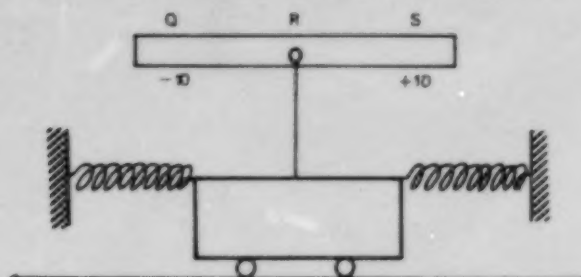
16 Which one of the following best represents the graph of velocity, v , against time for the same motion?



17 Which one of the following best represents the graph of acceleration, a , against time for the same motion?



Questions 18-22 refer to the following information:



A cart of mass 2 kg attached between two identical springs moves to and fro on a smooth surface. A pointer fixed to the top of the cart moves between points Q and S which are marked on a rule as shown in the diagram. A third point, R, is the point of equilibrium. Movement to the right is positive. At $t = 0$, the cart is released from Q. The scale on the rule is in cm.

- 18 The period of oscillation is π s. What is the restoring force per unit displacement, in N m^{-1} , acting on the cart?

A 0.5 C 4
B 1 D 8

- 19 What is the velocity of the cart, in m s^{-1} , when it is at S?

A 0 C 0.4
B 0.2 D unable to be determined from the information given

- 20 What is the speed of the cart, in m s^{-1} , when it is at R?

A 0 C 0.4
B 0.2 D unable to be determined from the information given

- 21 What is the total energy of the cart, in J, when at S?

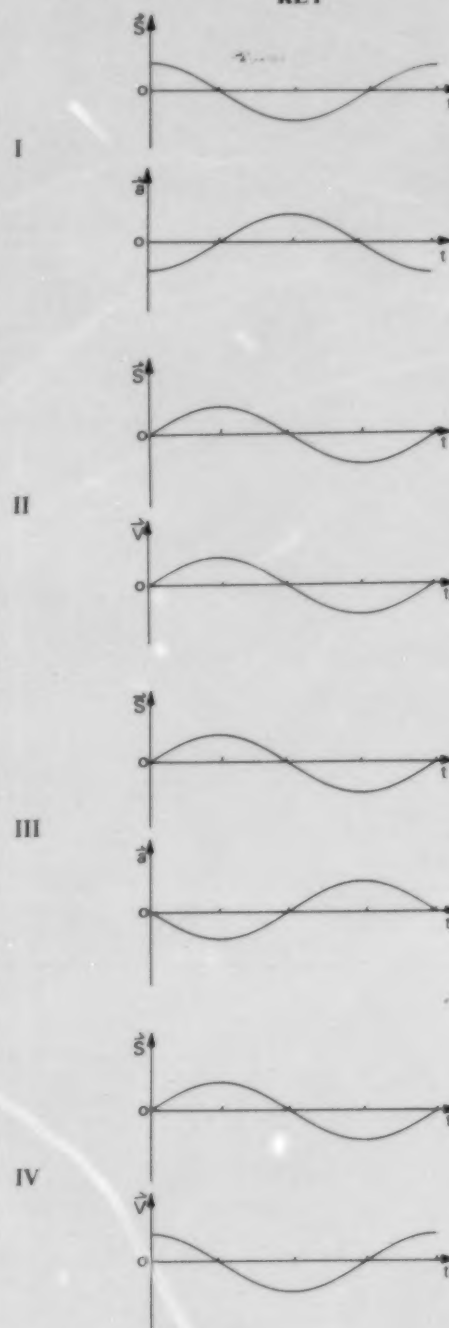
A 0 C 0.16
B 0.04 D 0.4

- 22 What is the total energy of the cart, in J, when at R?

A 0 C 0.16
B 0.04 D 0.4

- 23 A particle moves with simple harmonic motion. The key below shows four pairs of graphs. In the graphs, $\hat{s}$ represents the particle's displacement from the mean position, $\hat{a}$ represents its acceleration, $\hat{v}$ represents its velocity and t represents time.

KEY

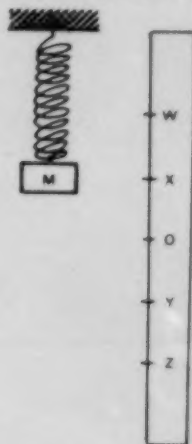


Which of the following pairs of graphs are consistent with each other?

A II only C I and IV only
B IV only D I, III and IV only

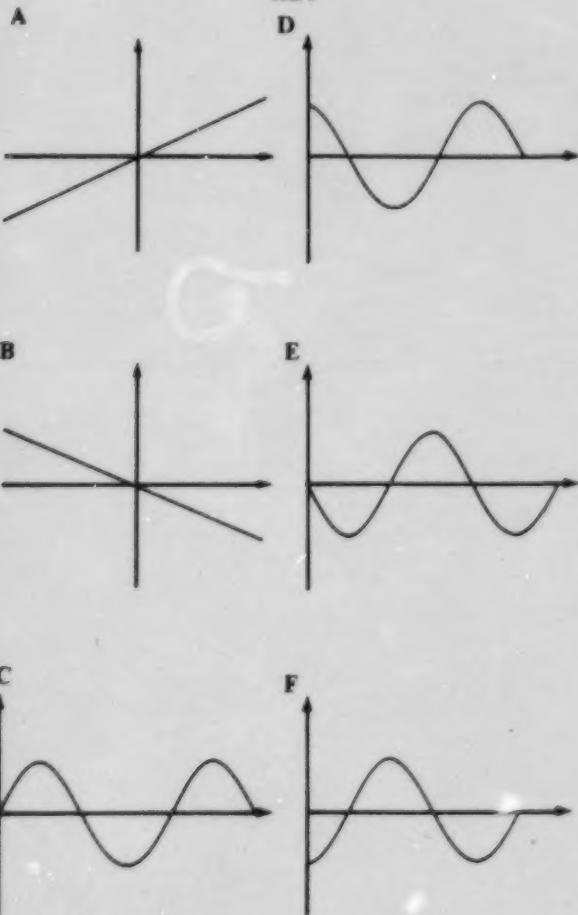
Questions 24–28 refer to the following information:

The diagram represents a system consisting of a body of mass m kg at the end of a spring. The body moves with simple harmonic motion between points X and Y marked on a rule. At time $t = 0$, the body is at X. The equilibrium position, O, is midway between X and Y. Displacements above this equilibrium position are assigned as positive. The period of the motion is T s.



The following key shows several graphs.

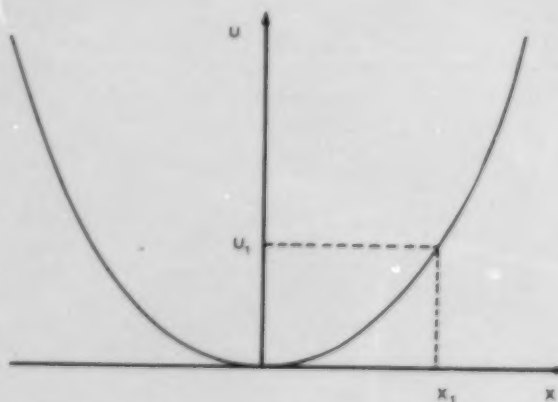
KEY



Use the key to answer Questions 24–28.

- 24 Which graph could represent the displacement-time relation for the body?
- 25 Which graph could represent the net force acting on the body with respect to time?
- 26 Which graph could represent the net force acting on the body with respect to position?
- 27 The amplitude of the motion is doubled, so that the body now oscillates between W and Z. What is the period of this motion?
- A $\frac{T}{4}$ C T
 B $\frac{T}{2}$ D $2T$
 E $4T$
- 28 What is the magnitude of the ratio
 total energy of system when body oscillates between W and Z
 total energy of system when body oscillates between X and Y ?
- A $\frac{1}{4}$ C $\frac{1}{1}$
 B $\frac{1}{2}$ D $\frac{2}{1}$
 E $\frac{4}{1}$

- 29 A mass m is moving with simple harmonic motion. A plot of potential energy (U) versus displacement (x) is shown below.

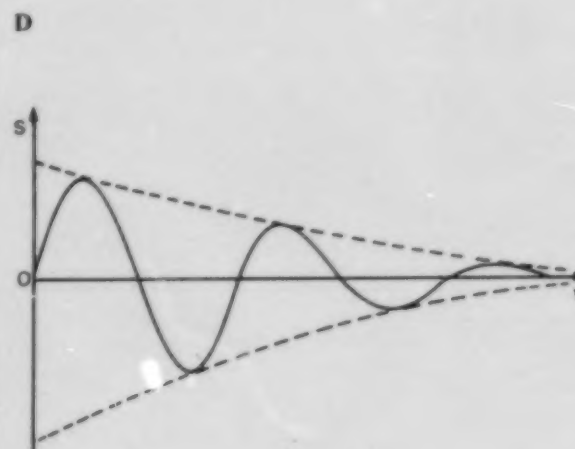
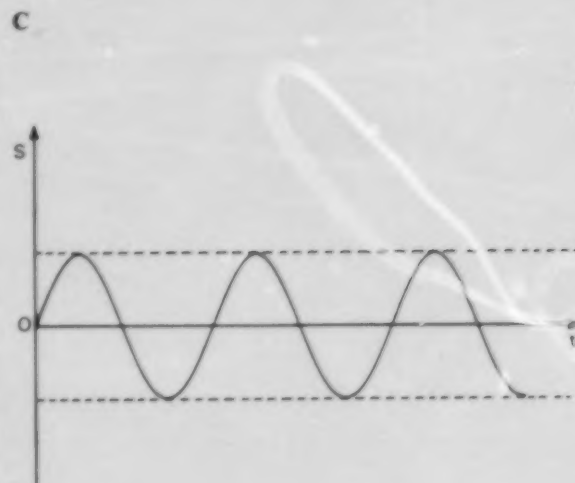
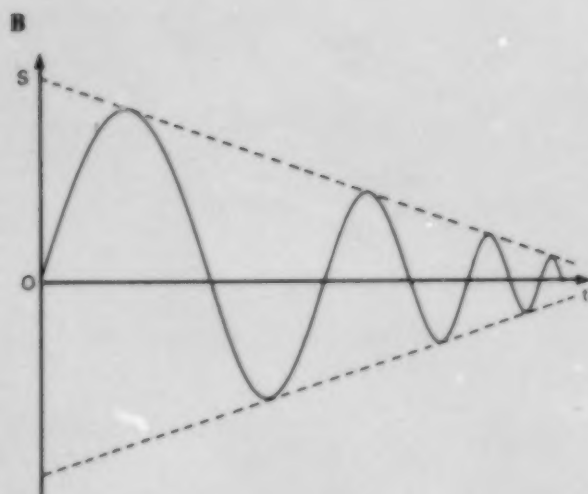
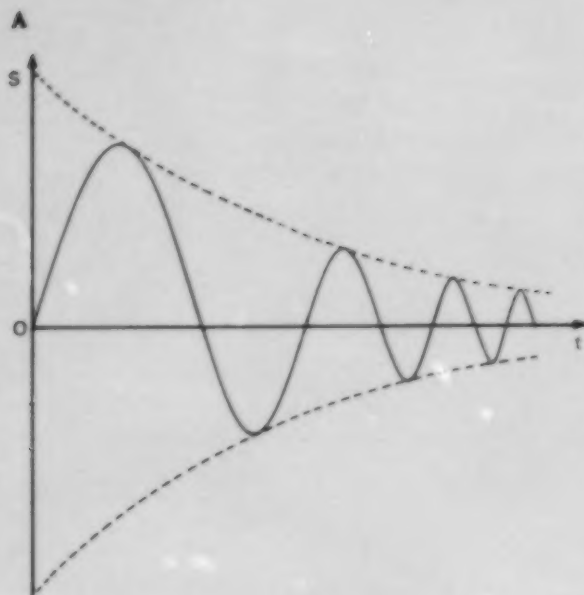


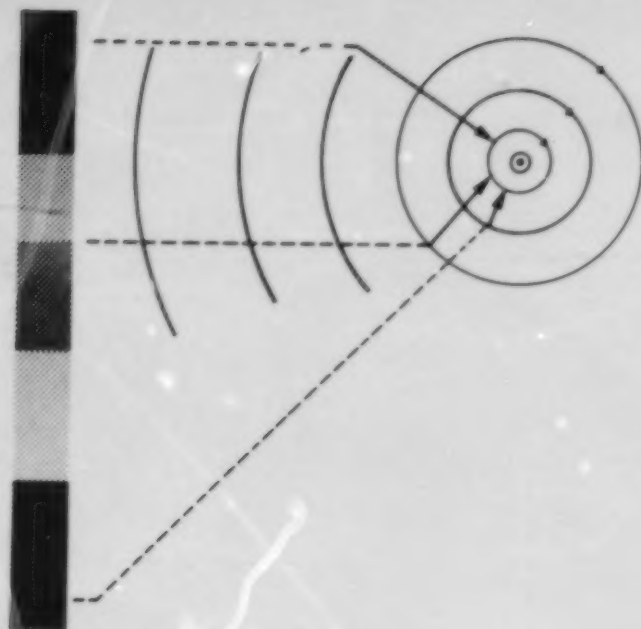
The total energy is E_0 . The potential energy is U_1 for a displacement of x_1 .

What is the speed of the mass at position x_1 ?

- A $\frac{E_0 - U_1}{2m}$ C $\sqrt{\frac{2(E_0 - U_1)}{m}}$
 B $\sqrt{\frac{E_0 - U_1}{m}}$ D $\frac{2(E_0 - U_1)}{m}$

30 Which one of the following graphs of displacement versus time best represents the motion of a particle undergoing damped SHM?





Test 9 Gravity and Kepler's laws

Directions

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- 1 Take the acceleration due to gravity, g as 10 m s^{-2} .
- 2 Where required by the calculations, take

$$\sin 30^\circ = \frac{1}{2} = 0.50.$$

$$\sin 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\sin 60^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 30^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\cos 60^\circ = \frac{1}{2} = 0.50.$$

$$\tan 30^\circ = \frac{1}{\sqrt{3}} = 0.58.$$

$$\tan 45^\circ = 1$$

$$\tan 60^\circ = \sqrt{3} = 1.73$$

- 3 Unless otherwise instructed, neglect air resistance.

Jottings and calculations should be done on a separate sheet of paper.

Do not write on this test booklet
NOW TURN THE PAGE AND GO ON WITH THE TEST

- 1 Two masses, m_1 and m_2 , have their centres of mass separated by a distance r .
The following key lists several products of these quantities.

KEY

I r^2

II $m_1 m_2$

III $(m_1 m_2)^{-1}$

IV r^{-2}

According to Newton's theory of gravitation the force exerted by m_1 on m_2 will be proportional to which of the following?

- A II only
B IV only
C I and III only
D II and IV only

- 2 Expressed in terms of SI fundamental quantities, the gravitational constant G has the units of
A $\text{m}^3 \text{kg}^{-1} \text{s}^{-2}$
B $\text{m}^2 \text{kg}^{-2} \text{s}^{-2}$
C $\text{m}^3 \text{kg}^{-2} \text{s}^{-1}$
D $\text{m} \text{kg}^{-2}$

- 3 If r is the radius of the earth and g_r is the acceleration due to gravity at its surface, then the acceleration g_R at a distance R from the centre of the earth (where $R > r$) is given by the expression

- A $\frac{g_R}{g_r} = \frac{r}{R}$
B $\frac{g_R}{g_r} = \frac{(R-r)^2}{r^2}$
C $\frac{g_R}{g_r} = \frac{r^2}{R^2}$
D $\frac{g_R}{g_r} = \frac{R^2}{r^2}$

- 4 Kepler's major contribution to the field of astronomy came from his
A use of accurate scientific instruments.
B careful astronomical observations.
C invention of a new scientific technique.
D mathematical analysis of data collected by other men.

- 5 Which one of the following laws is fundamentally different from the others?
A Law of gravitation
B Law of elliptical orbits
C Law of areas
D Law of periods

- 6 Neptune has two satellites; Triton, which has a period of revolution about Neptune of 58 days, and Nereid, which has a period of revolution of 360 days.

The average radii of the two orbits, $\frac{R_T}{R_N}$, is

- A $\frac{5.8}{360}$
B $\sqrt{\left(\frac{5.8}{360}\right)^2}$
C $\sqrt{\left(\frac{5.8}{360}\right)^3}$
D $\frac{360}{5.8}$

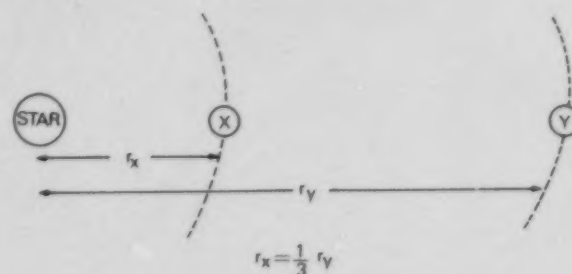
Questions 7-11 refer to the following information:

$T^2 = kR^3$ expresses the relationship between the period and orbital radius of a planet that revolves around a star.

- 7 The value of k can be changed by altering
A the mass of the planet.
B the period of the planet.
C the mass of the star.
D the orbital radius of the planet.

Questions 8-11 refer to the following additional information:

The diagram represents two planets, X and Y, which have circular orbits around the same star. The radius of the orbit of X is one third the radius of the orbit of Y.



- 8 What is the value of the ratio $\frac{\text{period of X}}{\text{period of Y}}$?

- A $\frac{3\sqrt{3}}{1}$
B $\frac{\sqrt{9}}{1}$
C $\frac{1}{\sqrt[3]{9}}$
D $\frac{1}{3\sqrt{3}}$

- 9 What is the value of the ratio $\frac{\text{orbital speed of X}}{\text{orbital speed of Y}}$?

- A $\frac{3}{1}$
B $\frac{\sqrt{3}}{1}$
C $\frac{1}{\sqrt{3}}$
D $\frac{1}{3}$

- 10 What is the value of the ratio $\frac{\text{acceleration of X}}{\text{acceleration of Y}}$?

- A $\frac{9}{1}$
B $\frac{3}{1}$
C $\frac{1}{3}$
D $\frac{1}{9}$

- 11 Suppose the planets X and Y are now orbiting two stars of different masses, with $r_X = \frac{1}{3}r_Y$. Which of the following statements about $\frac{\text{period of X}}{\text{period of Y}}$ is now correct?

- A The ratio will have the same value as in Question 8, as the ratio of radii is the same.
 B The ratio will have the same value as in Question 8, as G is a universal constant.
 C The ratio may not have the same value as in Question 8, as the masses of the planets may not be the same.
 D The ratio may not have the same value as in Question 8, as the two planets are now orbiting different central bodies.

- 12 Details of the mass and radius of Earth and the moon are given below.

	mass	radius
Earth	$6 \times 10^{24} \text{ kg}$	$6.4 \times 10^6 \text{ m}$
moon	$7.3 \times 10^{22} \text{ kg}$	$1.7 \times 10^6 \text{ m}$

The gravitational force on the moon due to Earth is approximately $2 \times 10^{20} \text{ N}$.

The force which the moon exerts on Earth is closest to

- A zero. C $2 \times 10^{20} \text{ N}$.
 B $3 \times 10^{12} \text{ N}$. D neither A nor B nor C.

- 13 A man stands on the earth's surface. The gravitational force exerted on the man by the earth (i.e. his weight) is W newton at the earth's surface. What net resultant force will be exerted on the earth?

- A 0 N C W N
 B $\frac{W}{2} \text{ N}$ D $2W \text{ N}$

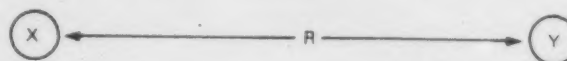
- 14 The average radius of orbit of the satellite Ariel about the planet Uranus is $1.9 \times 10^8 \text{ m}$, and its period of revolution is $2.2 \times 10^5 \text{ s}$. If the universal constant of gravitation, G, is $6.7 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$,

then the mass of Uranus is given by

- A 8.4×10^{25} C 1.5×10^{22}
 B 2.4×10^{25} D 2.5×10^{21}

Questions 15-18 refer to the following information:

Two objects, X of mass M and Y of mass 2M, are placed a distance R apart as shown in the diagram.



The gravitational force exerted on X by Y is F.

- 15 What is the magnitude of the gravitational force exerted on Y by X?

- A $\frac{F}{4}$ C F
 B $\frac{F}{2}$ D 2F
 E 4F

- 16 What is the magnitude of the gravitational force exerted on X by Y if the mass of X is doubled?

- A $\frac{F}{4}$ C F
 B $\frac{F}{2}$ D 2F
 E 4F

- 17 If, instead of changing the mass of X, the distance between the centres of mass is doubled, what is the magnitude of the gravitational force exerted on X by Y?

- A $\frac{F}{4}$ C F
 B $\frac{F}{2}$ D 2F
 E 4F

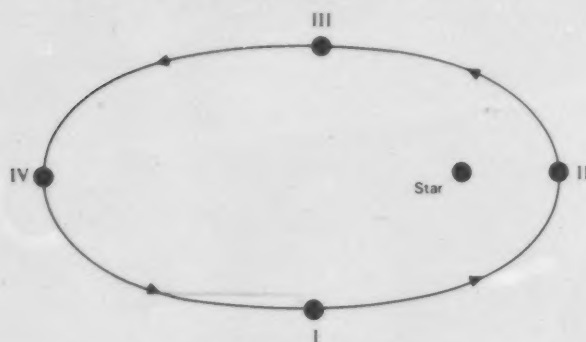
- 18 If both changes are made, that is, the mass of X is doubled and the distance between the centres of mass is doubled, what is the gravitational force exerted on X by Y?

- A $\frac{F}{4}$ C F
 B $\frac{F}{2}$ D 2F
 E 4F

- 19 A planet of mass M_1 has a small satellite of mass m_1 revolving around it at distance R, while a second planet of mass M_2 has another small satellite of mass m_2 revolving around it, also at distance R. The period of the satellite of mass m_1 is twice as long as the period of the satellite of mass m_2 . What is the ratio of the masses of the planets?

- A $M_1 = 4 M_2$ C $M_1 = 2 M_2$
 B $M_1 = \frac{M_2}{4}$ D $M_1 = \sqrt{2} M_2$

- 20 A planet moves in an elliptical orbit around a star which is at one focus, as shown in the diagram.



At what point in the planet's orbit will it be travelling fastest?

- A I
B II
C III
D IV
- 21 Which one of the following is the correct reason why the earth retains its atmosphere?
- A The velocity of escape is less than the mean speed of molecules.
B The constant of gravitation is a universal constant.
C The acceleration due to gravity decreases with height.
D The velocity of escape is greater than the mean speed of molecules.

Questions 22-24 refer to the following information:

The star Quirius has four planetary satellites revolving about it in elliptical orbits. They move in the same plane. They also rotate about their own axes.

The table shows the mean orbital radii and masses of the planets compared with the innermost planet, I.

Planet	Mean orbital radius	Mass
I	R_1	M_1
II	$4R_1$	$3M_1$
III	$9R_1$	$4M_1$
IV	$16R_1$	$14M_1$

- 22 What is the ratio

$\frac{\text{gravitational attraction between Quirius and I}}{\text{gravitational attraction between Quirius and III}}$?

- A $\frac{4}{9}$
B $\frac{9}{4}$
C $\frac{81}{4}$
D $\frac{16}{81}$

- 23 If the time taken by planet I to complete one rotation about its own axis is 1 ben, how long does planet III take to complete one rotation about its axis?

- A 1 ben
B 3 bens
C 9 bens
D 27 bens
E impossible to determine without further information.

- 24 If the time taken for planet I to complete one revolution around Quirius is 1 ding, how long does planet IV take to complete one revolution around Quirius?

- A 16 dings
B 64 dings
C 16^2 dings
D 64^2 dings
E impossible to determine without further information.

- 25 The moon always has the same face turned towards the earth. Using a frame of reference fixed with respect to the different stars, this implies that
- A the moon and Earth both rotate about their own axes at the same angular speed.
B the moon and Earth revolve around each other at the same speed.

- C the moon rotates approximately once about its own axis for each revolution around the earth.
D the moon does not rotate about its own axis.

- 26 In the formation of stars, it is believed that an extremely high initial temperature is needed resulting from

- A collisions involving meteorites or comets.
B energy released during gravitational collapse of the star-forming matter.
C combustion of the highly flammable elements making up part of the matter from which the star is formed.
D absorption of electromagnetic radiation from space.

ACER Physics Unit Tests

Test 10 Waves

Directions

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$$\tan 60^\circ = \sqrt{3} = 1.73$$

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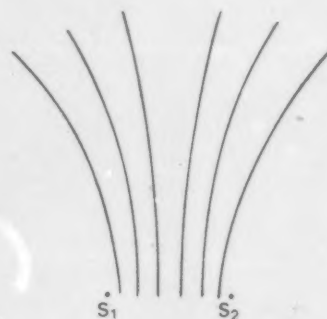
Jottings and calculations should be done on a separate sheet of paper.

Do not write on this test booklet
NOW TURN THE PAGE AND GO ON WITH THE TEST

- 1 The reciprocal of the frequency of a wave is known as the wave's
 - A amplitude.
 - B wavelength.
 - C period.
 - D displacement.
- 2 The distance a wave travels in the time for a complete vibration of its source is known as the wave's
 - A amplitude.
 - B frequency.
 - C wavelength.
 - D period.
- 3 At Sandy Beach last Tuesday the waves were breaking against the shore once every eight seconds, and there was a distance of 12 metres between each wave. At what speed were the waves travelling towards the shore?
 - A 0.66 m s^{-1}
 - B 1.5 m s^{-1}
 - C 20 m s^{-1}
 - D 96 m s^{-1}
- 4 During the passage of a longitudinal wave, the particles of the medium in which it travels vibrate
 - A parallel to the direction of energy flow.
 - B perpendicular to the direction of energy flow.
 - C randomly in all directions.
 - D uniformly in all directions.
- 5 The superposition of two waves travelling in opposite directions will produce a stationary wave with nodes of zero amplitude only if the waves have the same
 - A wavelength.
 - B frequency.
 - C amplitude.
 - D frequency and amplitude.
- 6 Which one of the following statements about two travelling waves must be true if a standing wave with nodal points is to be formed? The two waves have
 - A the same amplitude and travel in opposite directions.
 - B the same amplitude and travel in the same direction.
 - C different amplitudes and travel in opposite directions.
 - D different amplitudes and travel in the same direction.
- 7 The statement that 'two sources of waves are coherent' implies a relationship between which property of the two waves?
 - A speed
 - B amplitude
 - C frequency
 - D direction

Questions 8-10 refer to the following information:

Two point sources, S_1 and S_2 , in a ripple tank give rise to circular waves of the same amplitude. When the two sources are in phase, a stationary interference pattern results as shown, with nodal and antinodal lines.



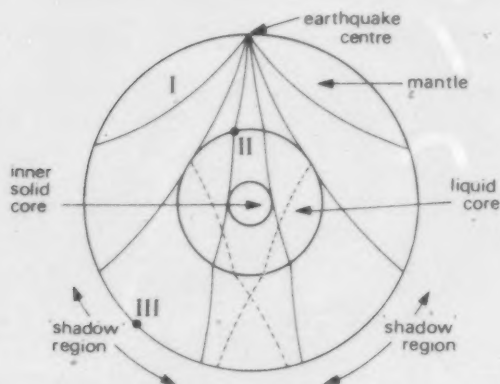
The following key should be used in answering Questions 8-10.

KEY

- I disappears completely.
 - II remains as a stationary pattern but with the nodal and antinodal lines interchanged.
 - III shows a continuous interchange of nodes and antinodes.
 - IV is of the same appearance as before except that the water is not completely calm at the nodal lines.
- 8 When the phase relation between the two sources is changed so that a constant phase difference of one half is maintained between them, then the interference pattern
 - A I.
 - B II.
 - C III.
 - D IV.
 - 9 If the two sources remain in phase but the amplitude of S_1 is twice the amplitude of S_2 , then the interference pattern
 - A I.
 - B II.
 - C III.
 - D IV.
 - 10 If the two sources have the same amplitude but the frequency of S_1 is slightly greater than the frequency of S_2 , then the interference pattern
 - A I.
 - B II.
 - C III.
 - D IV.

Questions 11-13 refer to the following information:

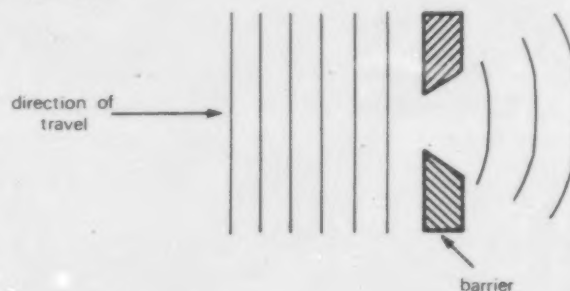
As a result of an earthquake in the earth's crust, several types of longitudinal waves are transmitted through the earth. The diagram represents a section through the earth showing some paths of these earthquake waves.



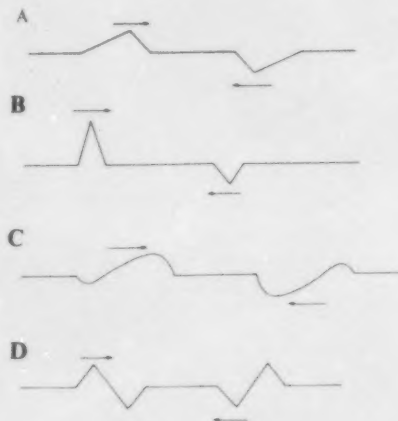
- 11 The path I in the mantle is curved because of
 A dispersion. C refraction.
 B diffraction. D reflection.
- 12 At point II on the boundary between the mantle and the core, the waves are seen to change direction.
 This change in direction suggests that
 A the speed of these waves in the mantle near II is greater than their speed in the core.
 B the speed of these waves in the mantle near II is less than their speed in the core.
 C the speed of these waves in the mantle near II is the same as their speed in the core.
 D no conclusion can be drawn regarding the speed of these waves from the information given.
- 13 Point III in one of the 'shadow' regions receives none of these waves because
 A refraction of the waves occurs on entering the liquid core.
 B reflection of the waves occurs at the mantle-liquid core interface.
 C pairs of waves cancel each other in this region.
 D the distance from the earthquake centre is so great that the waves are dispersed.

Questions 14 & 15 refer to the following information:

The diagram below illustrates straight waves in a ripple tank. The waves pass through a slit between the two barriers.



- 14 The phenomenon common to all types of wave motion which is illustrated in the diagram is
 A refraction. C reflection.
 B diffraction. D polarization.
- 15 If frequency of the waves was decreased
 A the waves would have more pronounced curvature after passing through the slit.
 B the 'shadow' region to the right of the slit would have a sharper boundary.
 C the wavelength would decrease by the same proportion.
 D the pattern would be unchanged.
- 16 Two identical tuning forks vibrate with a frequency of 180 cps. When small masses are added to the prongs of one tuning fork and the forks sounded together, 3 beats per second are heard. This means that the loaded tuning fork vibrates with a frequency of
 A 60 cps. C 183 cps.
 B 177 cps. D 540 cps.
- 17 Two pulses approach each other on a string. For which one of the following situations would the pulses completely cancel at some time during the interaction?



Questions 18-21 refer to the following information:

A uniform rope of length 20 m is attached at either end to pulse generators S_1 and S_2 . A point P is marked at the centre of the rope, as shown in Figure 1.

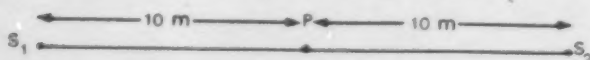


Figure 1

The pulses made by S_1 and S_2 each have amplitude 0.5 m and length 1 m, and are half-sine waves in shape as shown in Figure 2. These pulses travel at 5 m s^{-1} .



Figure 2

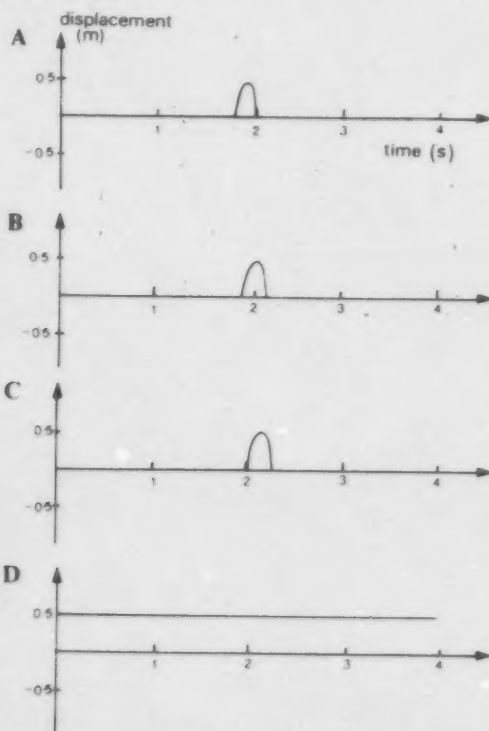
18 How long does it take to make a pulse of this type?

- A 0.2 s C 2 s
B 0.5 s D 5 s

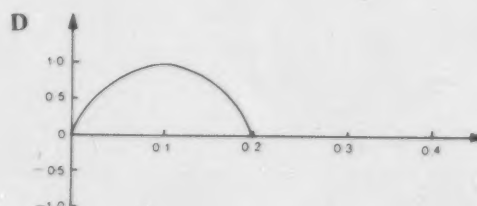
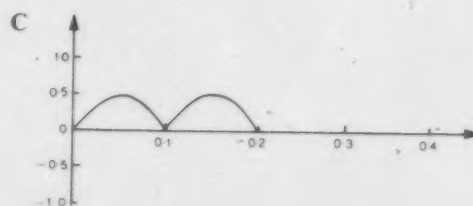
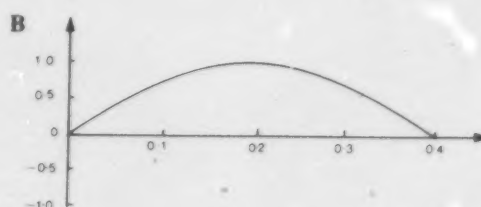
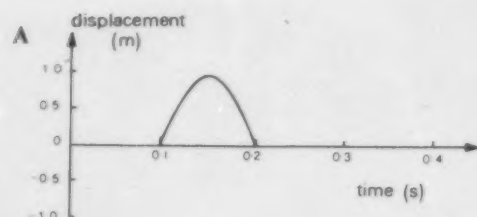
19 How long does it take for a pulse to travel from S_1 to P?

- A 0.5 s C 5 s
B 2 s D 10 s

20 A pulse starts from S_1 at time $t = 0$. If the rope was undisturbed apart from that pulse, which of the following sketches shows the displacement of the rope at P as a function of time from $t = 0$ to $t = 4 \text{ s}$?

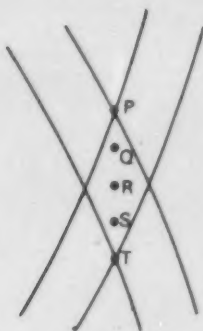


21 Suppose S_1 and S_2 each make one of these pulses simultaneously, and that the pulse from S_1 reached P at time $t = 0$. Which one of the following graphs best represents the displacement at P?



Questions 22 & 23 refer to the following information:

• X



• Y

The diagram shows an instantaneous picture of two pairs of wave peaks in a ripple tank. The waves have come from two similar vibrators X and Y and both have amplitude a . The spacing of the peaks is one wavelength. These peaks move on and are followed by others, giving an interference effect.

22 What is the amplitude of the resultant motion at P?

A 0

C $\frac{3}{2}a$

B a

D $2a$

23 What is the amplitude of the resultant motion at Q?

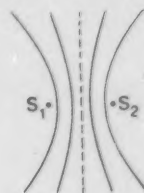
A

C $\frac{3}{2}a$

B a

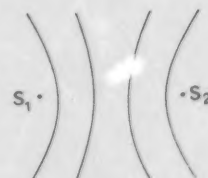
D $2a$

24 The diagram represents the interference pattern of water waves in a ripple tank created by two sources in phase. The continuous lines represent nodal lines, and the distance between the two sources, S_1 and S_2 , is d .

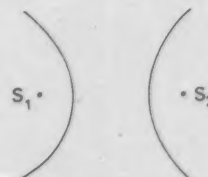


If the distance of separation of the sources is doubled while the frequency of the sources remains constant, which one of the following patterns would result?

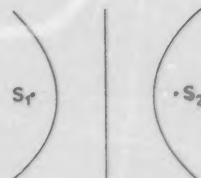
A



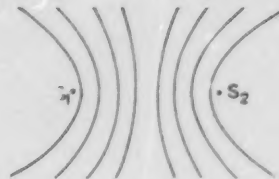
B



C

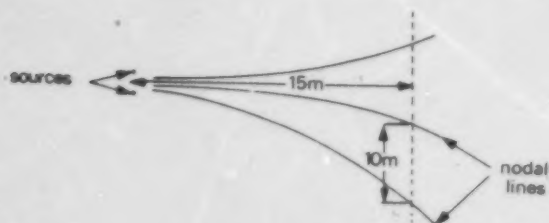


D



Questions 25-27 refer to the following information:

Two coherent sources of waves in a uniform medium produce an interference pattern such that, 15 m from the sources, the nodal regions are 10 m apart, as shown in the diagram.



- 25 The nodal spacing 20 m from the sources will be approximately

A 17.8 m. C 7.4 m.
B 13.3 m. D 6.6 m.

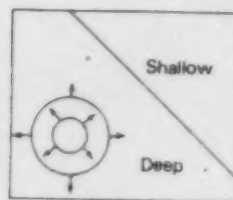
- 26 If the distance between the sources is 2 m, the wavelength of the waves is approximately

A 0.33 m. C 1.33 m.
B 0.75 m. D 1.80 m.

- 27 If the frequency of the sources is increased by a factor of three, the nodal spacing 15 m from the source will be

A 30 m. C $\frac{10}{9}$ m.
B $\frac{10}{3}$ m. D unable to be determined from the data given.

- 28 The diagram shows circular wave crests in a ripple tank with deep and shallow regions. Water waves travel faster in deep water than in shallow water.

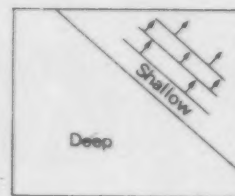


Which one of the following diagrams best shows the refracted wave crests?

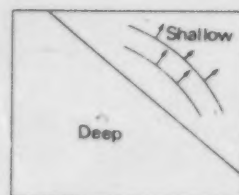
A



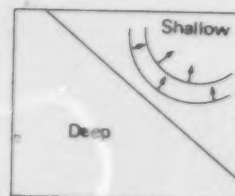
C



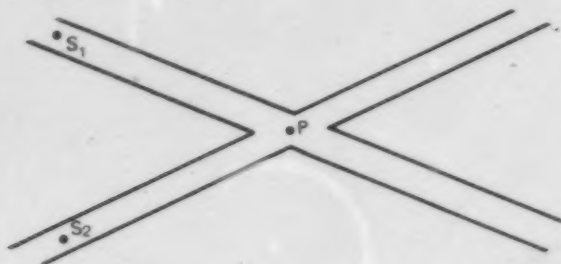
B



D



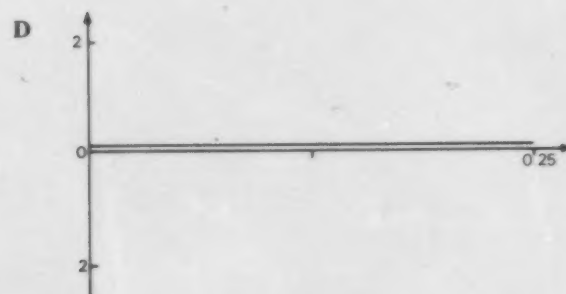
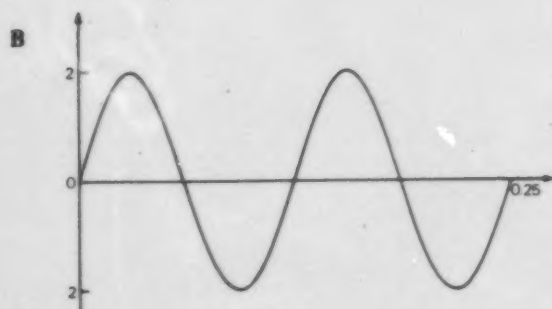
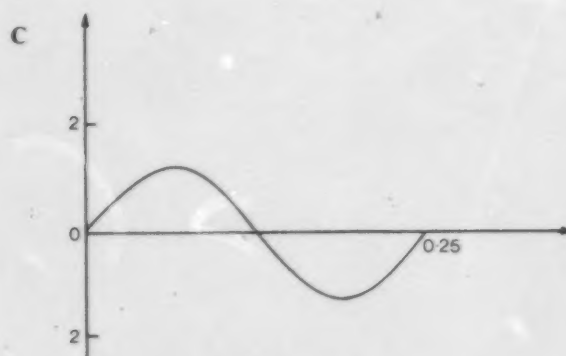
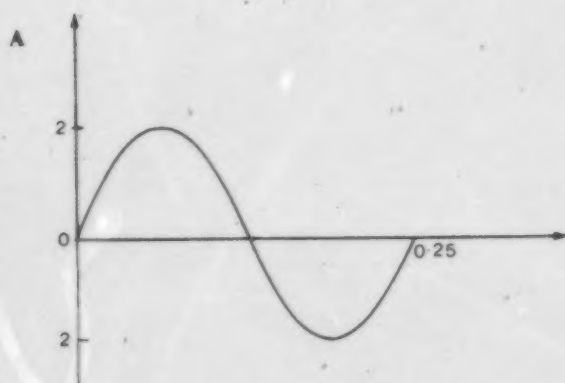
Questions 29 & 30 refer to the following information:
Water of uniform depth lies in an X-shaped container as shown in the diagram.



Sources S_1 and S_2 send out sine waves of amplitude 1 m and wavelength 2 m which travel *undiminished* at a speed of 8 m s^{-1} toward P. The distance S_1P is equal to the distance S_2P .

The following key shows four graphs.

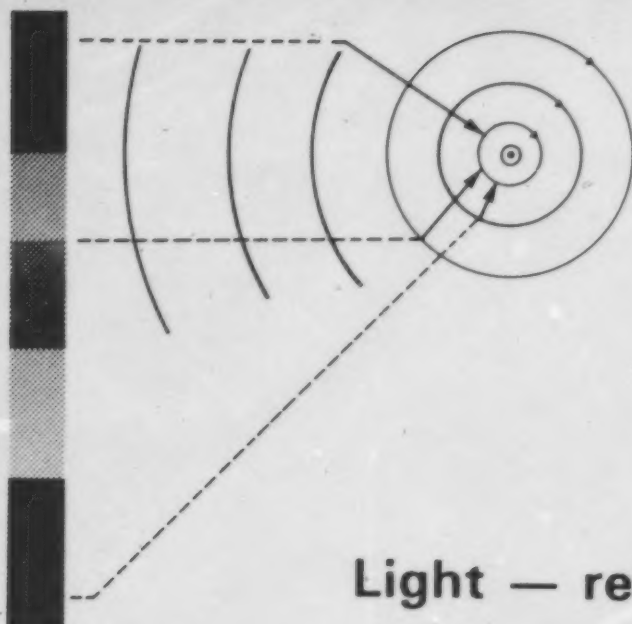
KEY



In answering Questions 29 & 30, select from the key the graph which best describes the displacement at P as a function of time under the conditions described.

29 If $S_1P = S_2P$ and S_1 and S_2 are in phase.

30 If $S_1P = S_2P$ and S_1 and S_2 are exactly out of phase (i.e. a phase difference of one half).



Test 11

Light — reflection and refraction

Directions

This test is designed to help you discover any difficulties and misunderstandings you may have in the work that you recently studied in your physics course. It is not intended to allocate a grade or mark to you as a result of taking the test. After completing and marking the test you will be able to make your own record of the questions that you were unable to answer correctly. This record will indicate the parts of the course to which you need to give further attention immediately.

When answering the questions keep these points in mind:

- 1 Do not spend too much time on any one question. If it seems too difficult omit it and go on to the next question.
- 2 For each question, several alternatives are given. You should choose the **best** answer from these alternatives.

The following information may be useful and should always be accepted where relevant.

- 1 Take the acceleration due to gravity, g as 10 m s^{-2} .
- 2 Where required by the calculations, take

$$\sin 30^\circ = \frac{1}{2} = 0.50.$$

$$\sin 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\sin 60^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 30^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\cos 60^\circ = \frac{1}{2} = 0.50.$$

$$\tan 30^\circ = \frac{1}{\sqrt{3}} = 0.58.$$

$$\tan 45^\circ = 1$$

$$\tan 60^\circ = \sqrt{3} = 1.73$$

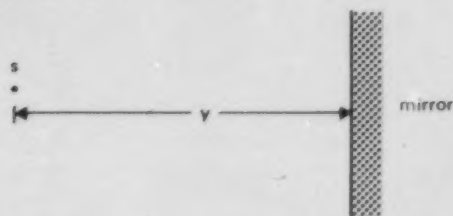
3. Unless otherwise instructed, neglect air resistance.

Jottings and calculations should be done on a separate sheet of paper.

Do not write on this test booklet
NOW TURN THE PAGE AND GO ON WITH THE TEST

Questions 1-4 refer to the following information:

A point source of light S is placed a distance y in front of a plane mirror.



- 1 After reflection from the mirror, the light rays are
A converging.
B diverging.
C parallel.

- 2 The image produced by the plane mirror is
A real.
B virtual.
C either real or virtual as it depends on the distance from the mirror.

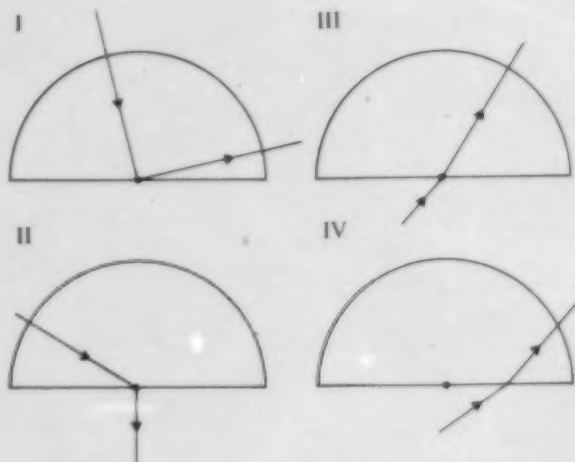
- 3 The distance between the object S and its image is
A y .
B $2y$.
C infinity.
D neither **A** nor **B** nor **C**.

- 4 If the point source is moved towards the mirror with speed V the image will
A move with speed V towards the mirror.
B move with speed V away from the mirror.
C move with speed $2V$ towards the mirror.
D move, but not with a speed of V or $2V$.

- 5 A real image formed by a single lens is always
A enlarged. **C** inverted.
B diminished. **D** upright.

- 6 A virtual image formed by a plane mirror is always
A upright.
B enlarged.
C on the same side of the mirror as the object.
D further away from the mirror than the object.

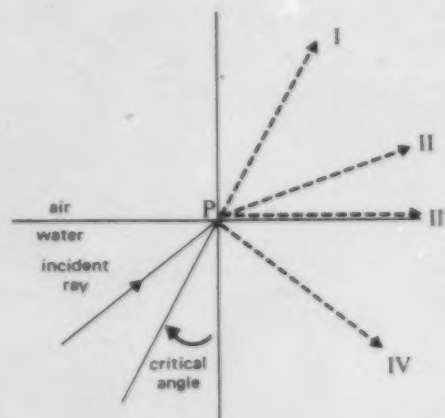
Question 7 refers to the following diagrams:



- 7 The diagrams show four suggested paths for a light ray passing through a semi-circular slab of glass. Only one of these paths could be correct. Which one?

- A** I **C** III
B II **D** IV

- 8 The diagram below shows a single light ray passing through water and incident on the boundary between the water and air at P . The magnitude of the critical angle is also shown.



Which one of the four broken lines I-IV shows the path followed by the light ray after it leaves P ?

- A** I **C** III
B II **D** IV

- 9 Three ray paths for light from an object placed to the left of a convex lens are shown below.

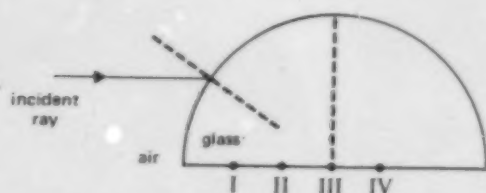


Which one of the following correctly describes the image formed by the lens?

The image is

- A real, upright and smaller than the object.
- B real, inverted and larger than the object.
- C virtual, upright and larger than the object.
- D virtual, inverted and smaller than the object.

- 10 The diagram shows a ray of light incident on a semi-circular slab of glass.

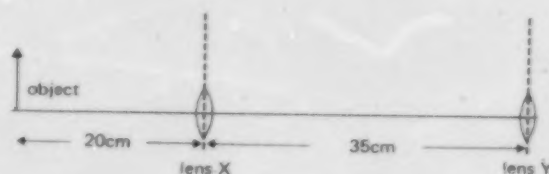


Which one of the four points on the base of the slab will the refracted ray most probably pass through?

- A I
- B II
- C III
- D IV

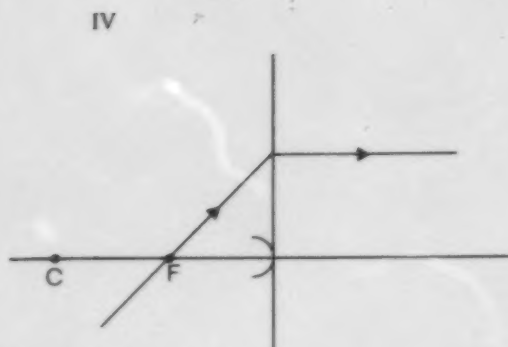
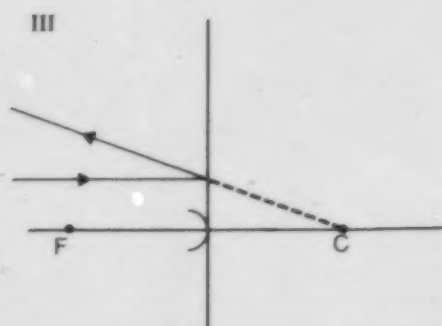
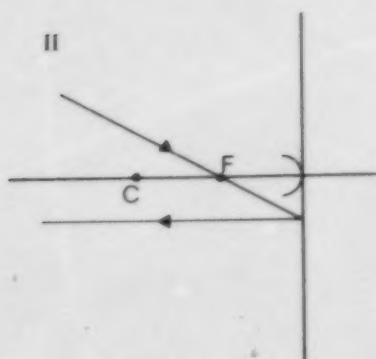
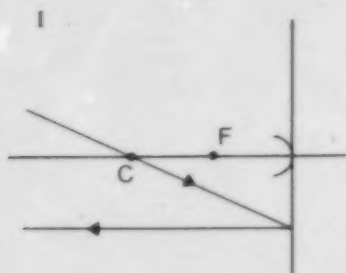
Questions 11-13 refer to following information:

The diagram below shows two identical converging lenses, with focal length $f = 10$ cm, separated by a distance equal to 35 cm. An object is placed a distance 20 cm to the left of the first lens.



- 11 The image of the object formed by the lens combination is
- A real and upright.
 - B real and inverted.
 - C virtual and upright.
 - D virtual and inverted.
- 12 Compared with the object, the image formed by the lens combination is
- A magnified by a factor 2.
 - B magnified by a factor $1\frac{1}{2}$.
 - C the same size as the object.
 - D reduced by a factor $1\frac{1}{2}$.
 - E reduced by a factor 2.
- 13 The image formed by the lens combination is positioned at
- A infinity.
 - B 15 cm to the left of lens Y.
 - C 15 cm to the right of lens Y.
 - D 30 cm to the right of lens Y.

- 14 The following diagrams show rays of light reflected by a spherical concave mirror. The point C represents the centre of curvature and F , the focal point.



Which one of the diagrams best shows the path of a light ray reflected by a concave mirror?

- A I C III
B II D IV

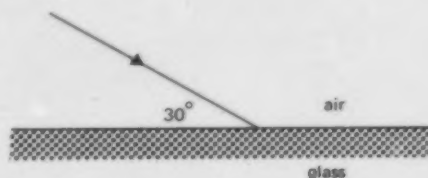
Questions 15–18 refer to the following information:

The refractive indices of water, glass and air may be taken as

water	$= \frac{4}{3}$
glass	$= \frac{3}{2}$
air	$= 1$

The following additional information is required for questions 15 and 16:

A beam of light strikes an air-glass boundary at an angle of 30° to the glass:



- 15 What is the angle of incidence?

- A 0° C 60°
B 30° D 150°

- 16 The sine of the angle of refraction is

- A $\frac{1}{3}$ C $\frac{3}{4}$
B $\frac{\sqrt{3}}{3}$ D $\frac{3\sqrt{3}}{4}$

- 17 In which one of the following may total internal reflection occur?

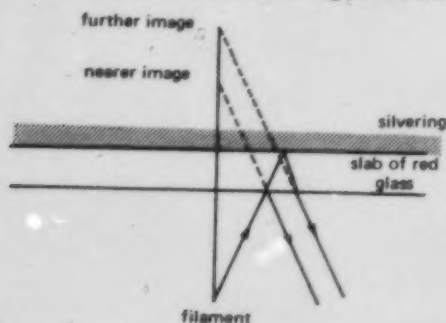
For light passing from

- A glass to water. C water to glass.
B air to glass. D air to water.

- 18 If V_A = speed of light in air,
 V_G = speed of light in glass, and
 V_W = speed of light in water,
which list correctly gives the order of increasing speed of light (least first)?

- A V_A, V_G, V_W C V_W, V_G, V_A
B V_W, V_A, V_G D V_G, V_W, V_A

Questions 19–22 refer to the following information:



White light from an electric lamp is reflected from a slab of red glass which is silvered on the back surface. In the diagram, rays appear to come from two images, one nearer the observer than the other.

- 19 The colour of the nearer image is
 A red.
 B silver.
 C green.
 D white.
 E neither A, nor B, nor C, nor D.

- 20 The colour of the further image is
 A red.
 B silver.
 C green.
 D white.
 E neither A, nor B, nor C, nor D.

Questions 21 & 22 refer to the following additional information:

A piece of green glass is placed between the lamp and the slab of red glass.

- 21 The colour of the nearer image is
 A red.
 B silver.
 C green.
 D white.
 E neither A, nor B, nor C, nor D.
- 22 The colour of the further image is
 A red.
 B silver.
 C green.
 D white.
 E neither A, nor B, nor C, nor D.
- 23 An object 25 cm from a convex lens forms a virtual image 75 cm from the lens.
 The focal length of the lens is
 A 18.75 cm.
 B 37.50 cm.
 C 50.00 cm.
 D neither A, nor B, nor C as it cannot be determined from the data.

Questions 24–26 refer to the following information:

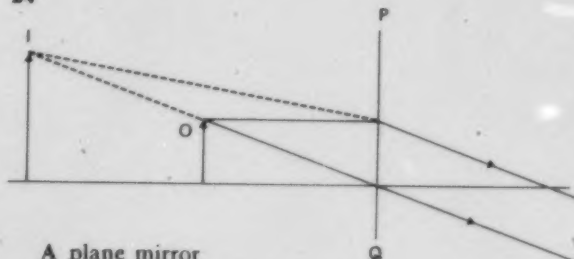
In each question, the ray diagram shows

an object O ,
 an image I , and

two rays from the object.

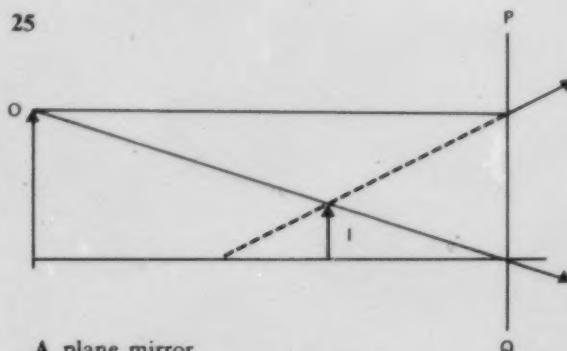
For each question, select which lens or mirror, when placed on the line PQ , would produce the image shown in the diagram.

24



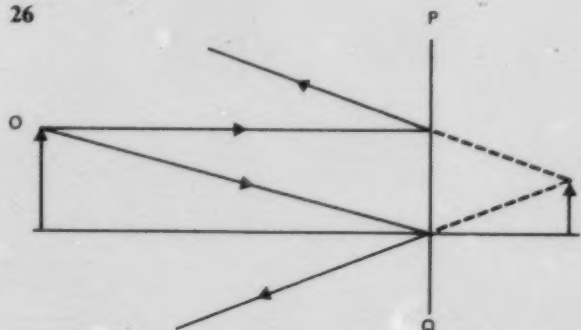
- A plane mirror
 B converging (concave) mirror
 C diverging (convex) mirror
 D converging (convex) lens
 E diverging (concave) lens

25



- A plane mirror
 B converging (concave) mirror
 C diverging (convex) mirror
 D converging (convex) lens
 E diverging (concave) lens

26



- A plane mirror
 B converging (concave) mirror
 C diverging (convex) mirror
 D converging (convex) lens
 E diverging (concave) lens

ACER PHYSICS UNIT TESTS

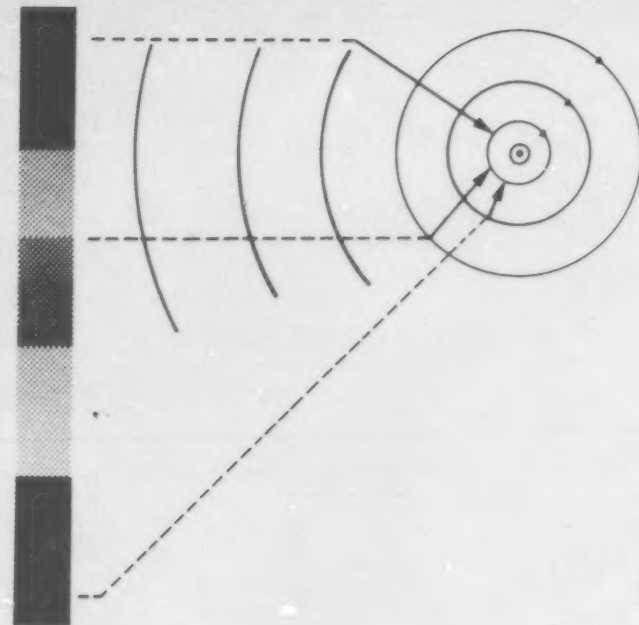
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I A series of tests covering the following topics

- 1 *Physical measurement*
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- 7 *Linear momentum*
- 8 *Oscillations*
- 9 *Gravity and Kepler's laws*
- 10 *Waves*
- 11 *Light – reflection and refraction*
- 12 *Light – interference, diffraction and spectra*
- 13 *Models of light*
- 14 *Kinetic theory of gases*
- 15 *Static charges*
- 16 *Electric field and potential differences*
- 17 *Current electricity*
- 18 *The magnetic field*
- 19 *Induced emf*
- 20 *Atomic physics*
- 21 *Quantum physics*

II Teachers Information Booklet

III List of Answers Booklet



Test 12

Light — interference, diffraction & spectra

Directions

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- 1 Take the acceleration due to gravity, g as 10 m s^{-2} .
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$$\sin 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\sin 60^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 30^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\cos 60^\circ = \frac{1}{2} = 0.50.$$

$$\tan 30^\circ = \frac{1}{\sqrt{3}} = 0.58.$$

$$\tan 45^\circ = 1$$

$$\tan 60^\circ = \sqrt{3} = 1.73$$

- 3 Unless otherwise instructed, neglect air resistance.

Jottings and calculations should be done on a separate sheet of paper.

Do not write on this test booklet
NOW TURN THE PAGE AND GO ON WITH THE TEST

- 1 Which one of the following properties of light gives evidence that light waves are *transverse* waves?

A diffraction C polarization
B interference D refraction

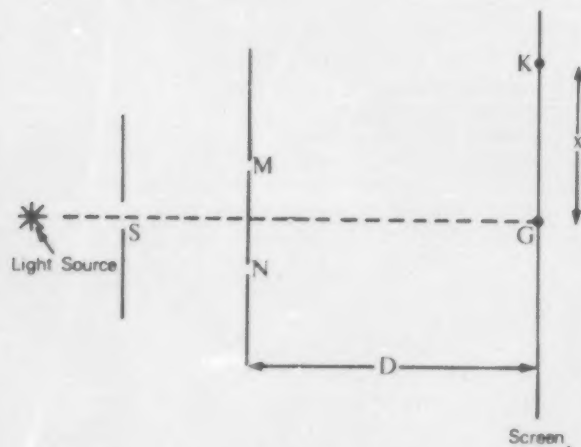
- 2 Light consisting of a mixture of various frequencies passes through a diffraction grating and is allowed to fall on a screen.

A bright central fringe appears plus successive pairs of fringes, one on either side, of decreasing brightness.

For any particular fringe, which of the following is true?

- A The lower frequencies have the larger angles of diffraction.
B The angle of diffraction is independent of the frequency of the light.
C The higher frequencies have the larger angles of diffraction.
D It is impossible to decide between A, B and C without knowing the size of the slit spacing in the diffraction grating.

Questions 3-7 refer to the following information:



The apparatus shown above is a diagrammatic representation of Young's experiment, in which light from a light source passes, first through a single slit, and then a double slit, before reaching a screen situated some distance away. A series of light and dark bands appear on the screen.

G is equidistant from slits M and N, and when using light of wavelength λ , K is a point such that

$$NK - MK = \frac{\lambda}{2}$$

- 3 On the screen one would expect to see

- A a dark band centred on G.
B a bright band centred on G.
C a boundary between a bright and a dark band passing through G.

- 4 On the screen, one would expect to see

- A a dark band centred on K.
B a bright band centred on K.
C a boundary between a bright and a dark band passing through K.

- 5 The whole apparatus is now immersed in water of refractive index $\frac{4}{3}$. The distance between successive dark bands

- A remains the same.
B increases to $\frac{4}{3}$ of its previous value.
C decreases to $\frac{3}{4}$ of its previous value.
D increases to $\sqrt{\frac{4}{3}}$ of its previous value.
E decreases to $\sqrt{\frac{3}{4}}$ of its previous value.

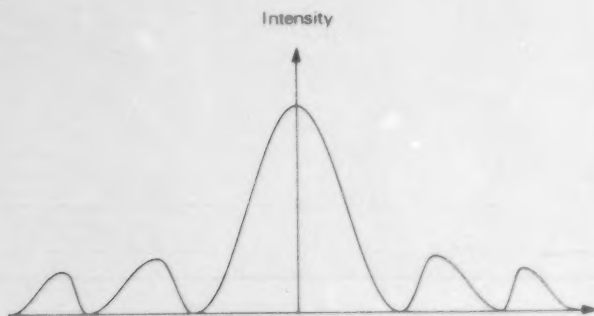
- 6 Which one of the following changes in the experimental design would cause the dark bands on the screen to be closer together?

- A The distance D be increased.
B The slit separation be decreased.
C The lamp be moved further away from the slit.
D The use of a source producing light of shorter wavelength.

- 7 Suppose that y is defined as the distance between successive dark bands. A device is now placed in front of M which delays the light beam by $\frac{\lambda}{2}$. The pattern on the screen then shifts up a distance

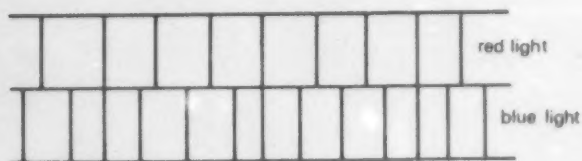
- A y . C $\frac{y}{4}$.
B $\frac{y}{2}$. D 0.

- 8 A parallel beam of monochromatic light is incident on a single slit. The intensity of the diffraction pattern is as shown.



The pattern can be explained if one assumes that

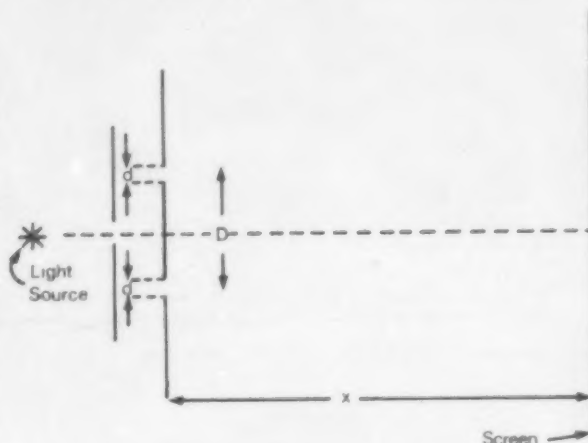
- A the two edges of the slit are acting as two point sources in phase.
 - B the slit is acting as a single point source.
 - C the slit is acting as two point sources with a phase difference of π .
 - D the slit is acting as a row of point sources in phase.
- 9 The diagram represents the interference patterns of red light and blue light made with exactly the same arrangement of two narrow slits. The interference pattern of red light is on top and the lines represent nodes.



What is the ratio $\frac{\text{wavelength of red light}}{\text{wavelength of blue light}}$?

- A $\frac{9}{13}$
- B $\frac{13}{9}$
- C $\frac{3}{4}$
- D $\frac{4}{3}$

Questions 10-13 refer to the following information:
Below is a diagrammatic representation of Young's Double-Slit experiment.



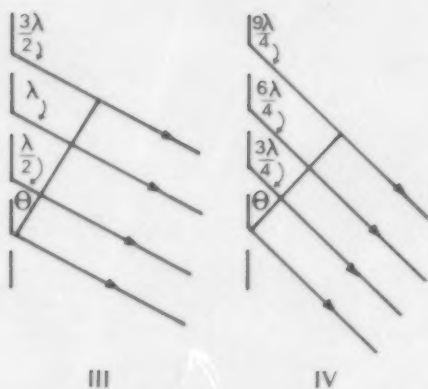
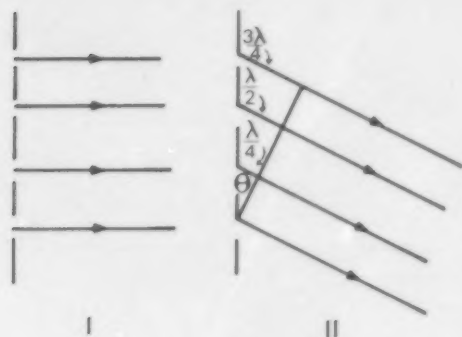
The following key should be used in answering Questions 10-12:

- A multiplied by 4
- B multiplied by 2
- C multiplied by $\sqrt{2}$
- D no change
- E divided by $\sqrt{2}$
- F divided by 2
- G divided by 4

In answering Questions 10-12, state what happens to the width of the bands of the interference pattern on the screen when

- 10 the distance between the slits, D , is doubled.
- 11 the width of the slits, d , is doubled.
- 12 the distance between the slits and the screen, x , is doubled.
- 13 If, in the above experiment, $x = 2$ m, $D = 0.1$ mm and red light of wavelength 7×10^2 nm is used, what is the resulting width of the bands produced?
 - A 7×10^1 m
 - B 2×10^{-2} m
 - C 1.4×10^{-2} m
 - D 3.5×10^{-11} m

- 14 The diagrams represent five different situations after light enters four equally spaced narrow slits of width d .



Light is shown leaving the slits at five different angles, given by

$$\sin \theta = 0, \frac{\lambda}{4d}, \frac{\lambda}{2d}, \frac{3\lambda}{4d}, \frac{\lambda}{d}$$

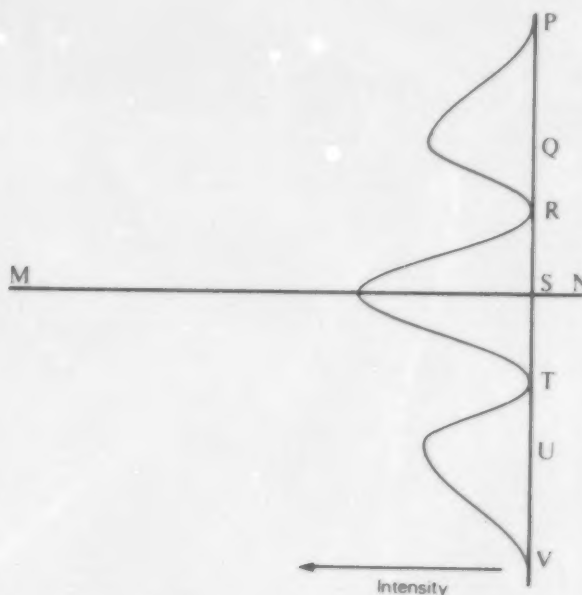
At which set of angles listed below would nodes be expected in the interference pattern formed on a screen a large distance from the slits?

- A II and III only C II, III and IV only
B I, II and III only D II, III, IV and V only

Questions 15-17 refer to the following information:

Below is an intensity graph of an interference pattern obtained by a Young's Double-Slit Interference experiment.

MN is the line of symmetry of the apparatus. The wavelength of the light is λ .



Questions 15-17 apply to the above points P-V.

- 15 At which point, or points, indicated is the optical path difference of the light from each of the slits equal to the wavelength of light used?

- A S only C Q and U
B R and T D Q, S and U

- 16 At which point, or points, indicated is the optical path difference of the light from each of the slits to the screen equal to $\frac{3}{2}\lambda$?

- A S only C Q, S and V
B P and V D P, R, T and V

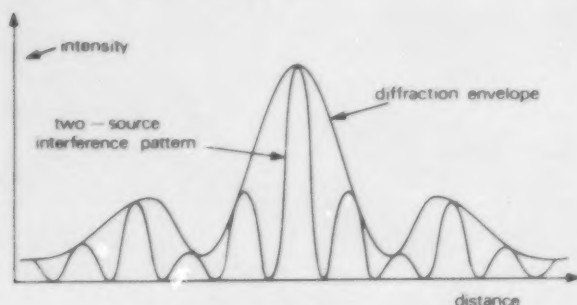
- 17 At which point, or points, indicated is the optical path difference of the light from each of the slits to the screen equal to zero?

- A S only C Q, S and U
B R and T D R, S and T

Questions 18-20 refer to the following information:

In an experiment in which laser light passes through two adjacent slits, an interference pattern is observed on a screen.

The variation of intensity with distance for the pattern is shown below.



In answering Questions 18-20, the following key should be used:

KEY

- I the interference pattern becomes wider and the diffraction envelope becomes wider
- II the interference pattern becomes narrower and the diffraction envelope becomes narrower
- III the interference pattern becomes narrower but the width of the diffraction envelope is unchanged
- IV the interference pattern is unchanged but the diffraction envelope becomes narrower

18 When the wavelength of the laser light is reduced, and all other factors held constant, then

A I. C III.

B II. D IV.

19 When the slit widths are both increased but the wavelength and slit separation are kept constant, then

A I. C III.

B II. D IV.

20 When the wavelength, slit widths and slit separation are kept constant but the distance from slits to screen is increased, then

A I. C III.

B II. D IV.

21



The diagram shows an arrangement for using interference patterns for measuring the thickness of thin objects. When viewed from above with monochromatic light of wavelength 6.0×10^2 nm, 100 nodal lines were observed.

The thickness of the material was

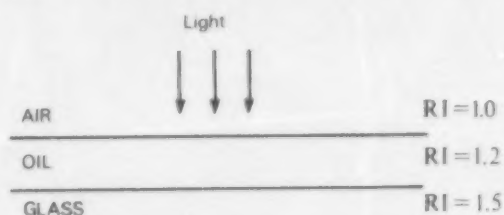
A 6.0×10^1 nm.

B 3.0×10^1 nm.

C 6.0 nm.

D neither A nor B nor C as it cannot be determined unless the refractive index of glass is known.

22 Light from a sodium lamp ($\lambda = 600$ nm) is directed perpendicularly on to a thin layer of oil of refractive index (R.I.) equal to 1.2, lying on a sheet of glass (R.I. = 1.5).



What is the least thickness of oil film that gives a minimum intensity of reflected light?

A 100 nm. C 250 nm.

B 125 nm. D 300 nm.

23 When viewed from different angles an oil film on the surface of water often shows bands of different colours. These colours are mainly produced because

A only certain colours are reflected from the oil film.

B refraction of light occurs within the oil film thus producing spectral colours.

C light reflected from two surfaces of the film produces interference effects.

D certain colours are absorbed by the oil film.

- 24 A diffraction grating of width x metres has a total of n lines. Light of wavelength λ is normally incident on the grating. The relation between the angle θ , through which the first order beam is diffracted, and the wavelength λ is

$$\text{A } \sin \theta = \frac{n\lambda}{x} \quad \text{C } \sin \theta = \frac{\lambda x}{n}$$

$$\text{B } \theta = \frac{x \sin \lambda}{n} \quad \text{D } \sin \theta = \frac{\lambda}{n}$$

Questions 25 & 26 refer to the following information:

Light from various sources is dispersed by a prism. The sources are:

- P — a tungsten filament lamp
- Q — a mercury vapour lamp
- R — a tungsten filament lamp surrounded by green plastic
- T — a hydrogen discharge tube

- 25 For which of the above sources does a line spectrum result?

- A P only
- B Q and R only
- C Q and T only
- D P, Q, R and T

- 26 For which of the above sources does a continuous spectrum result?

- A P only
- B Q only
- C R only
- D T only

- 27 Fraunhofer lines can be classified as part of the

- A band emission spectrum.
- B band absorption spectrum.
- C line emission spectrum.
- D line absorption spectrum.

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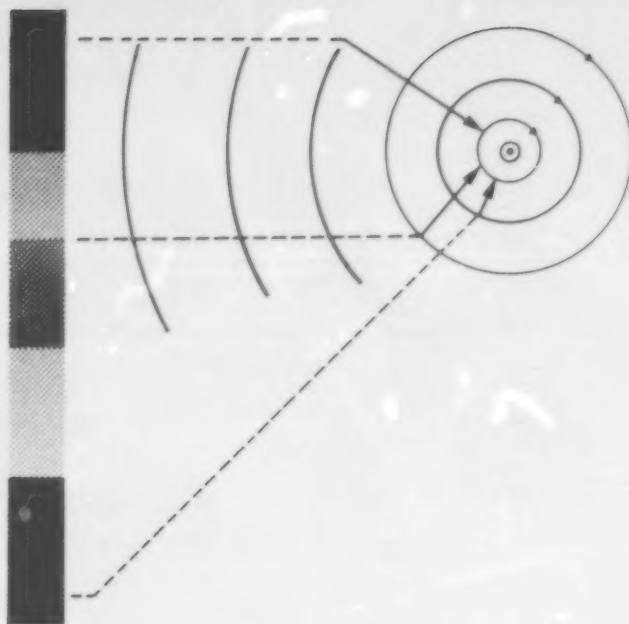
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I A series of tests covering the following topics

- 1 *Physical measurement*
- 2 *Vectors*
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- 5 *Dynamics*
- 6 *Work and energy*
- 7 *Linear momentum*
- 8 *Oscillations*
- 9 *Gravity and Kepler's laws*
- 10 *Waves*
- 11 *Light – reflection and refraction*
- 12 *Light – interference, diffraction and spectra*
- 13 *Models of light*
- 14 *Kinetic theory of gases*
- 15 *Static charges*
- 16 *Electric field and potential difference*
- 17 *Current electricity*
- 18 *The magnetic field*
- 19 *Induced EMF*
- 20 *Atomic physics*
- 21 *Quantum physics*

II Teachers Information Booklet

III List of Answers Booklet



Test 13 Models of light

Directions

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When answering the questions keep these points in mind:

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- 2 For each question, several alternatives are given. You should choose the **best** answer from these alternatives.

The following information may be useful and should always be accepted where relevant.

- 1 Take the acceleration due to gravity, g as 10 m s^{-2} .
- 2 Where required by the calculations, take

$$\sin 30^\circ = \frac{1}{2} = 0.50.$$

$$\sin 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\sin 60^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 30^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\cos 60^\circ = \frac{1}{2} = 0.50.$$

$$\tan 30^\circ = \frac{1}{\sqrt{3}} = 0.58.$$

$$\tan 45^\circ = 1$$

$$\tan 60^\circ = \sqrt{3} = 1.73$$

3. Unless otherwise instructed, neglect air resistance.

Jottings and calculations should be done on a separate sheet of paper.

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- 1 When a wave changes direction as it passes from one medium to another, there is also an alteration to its

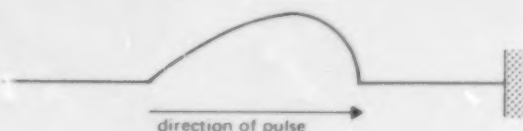
A wavelength and velocity.
 B wavelength and frequency.
 C frequency and velocity.
 D wavelength, frequency and velocity.

- 2 The speed of light in air (refractive index = 1) is $3 \times 10^8 \text{ m s}^{-1}$. What is the speed of light in glass (refractive index = 1.5)?

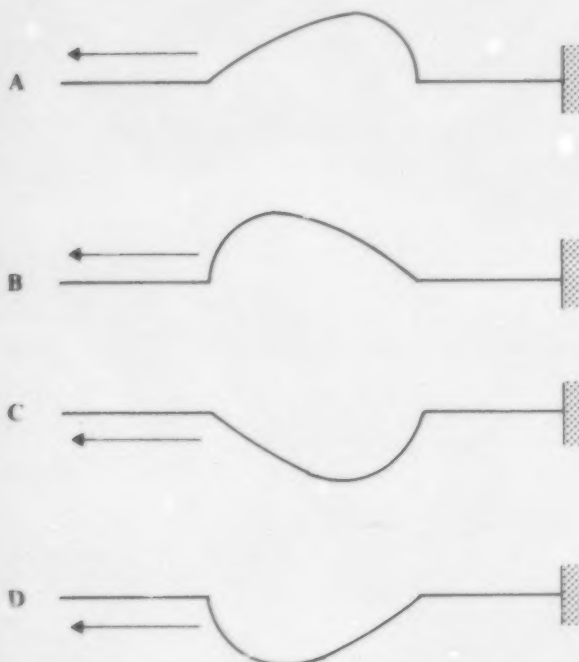
A $1.5 \times 10^8 \text{ m s}^{-1}$ C $3 \times 10^8 \text{ m s}^{-1}$
 B $2.0 \times 10^8 \text{ m s}^{-1}$ D $4.5 \times 10^8 \text{ m s}^{-1}$

Questions 3 & 4 refer to the following information:

The diagram below shows a pulse travelling along a string towards a fixed support.



- 3 Which one of the following diagrams correctly shows the shape of the pulse after reflection?



- 4 What is the phase change in the pulse?

A 0 C $\frac{1}{2}$
 B $\frac{1}{4}$ D 1

Questions 5-7 refer to the following information:

A light wave moving from medium 1 to medium 2 is refracted at the interface. The direction of propagation is shown.

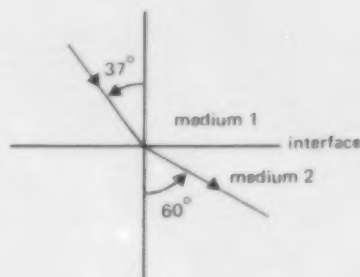


Table of sines

$\sin 30^\circ = 0.5$
 $\sin 37^\circ = 0.6$
 $\sin 53^\circ = 0.8$
 $\sin 60^\circ = 0.9$

v_1 and v_2 denote the speeds of the waves in media 1 and 2 respectively.

- 5 Which one of the following could be the angle between the interface and the refracted wave?

A 23° C 53°
 B 30° D 60°

- 6 What value for $\frac{v_2}{v_1}$ is predicted by the wave model of light?

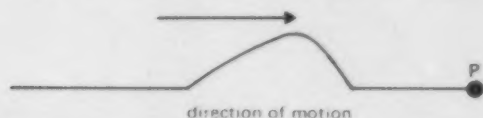
A $\frac{4}{9}$ C $\frac{9}{4}$
 B $\frac{2}{3}$ D $\frac{3}{2}$

- 7 What is the value of the ratio

$\frac{\frac{v_2}{v_1} \text{ predicted by the particle model}}{\frac{v_2}{v_1} \text{ predicted by the wave model}}$?

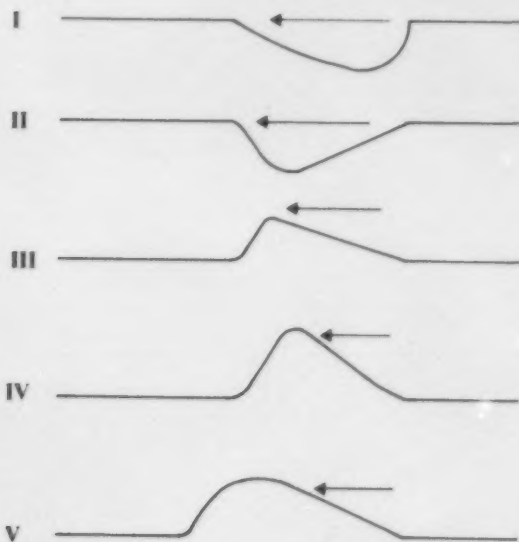
A $\frac{4}{9}$ C 1
 B $\frac{2}{3}$ D $\frac{9}{4}$

Questions 8 & 9 refer to the following information:



The diagram represents a pulse generated on a string. Reflected pulses were later observed passing back over the string.

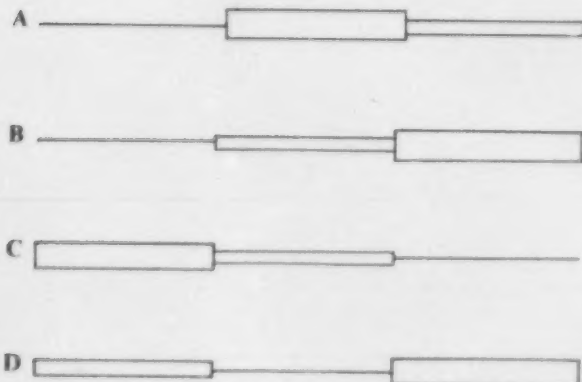
Diagrams I to V represent possible reflections in a similar piece of string.



8 Which of the pulses could be reflections of the original pulse?

- A I and II C I, III and IV
B II and III D III, IV and V

9 Suppose that the pulse passes along a string of three sections of varying thicknesses. Assume that the first reflected pulse observed passing back over the string has a downward displacement; the second has an upward displacement. Which of the following could represent the extension of the string to the right of P in the diagram?



10 The particle model of light is only partially successful in explaining refraction. This is because it does not predict that light would

- A obey Snell's law.
B change direction when it passes from one medium to another.
C travel faster in water than in air.
D travel faster in air than in water.

11 The laws of reflection

- A may be explained in terms of a particle model of light but not a wave model.
B may be explained in terms of a wave model but not a particle model of light.
C may be explained in terms of both wave and particle models of light.
D cannot be explained in terms of either a particle or a wave model of light.

12 Diffraction

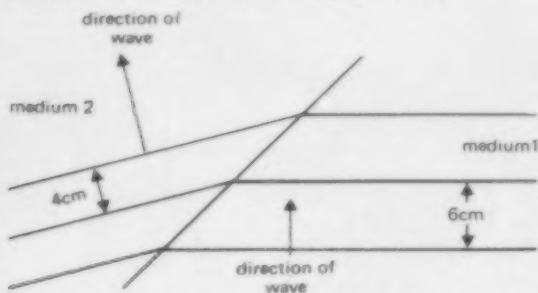
- A may be explained in terms of a particle model of light but not a wave model.
B may be explained in terms of a wave model but not a particle model of light.
C may be explained in terms of both wave and particle models of light.
D cannot be explained in terms of either a particle or a wave model of light.

13 Which one of the following can **not** be explained successfully by the particle model of light?

- A the simultaneous reflection and refraction of light as an interface of two media
B the variation of the intensity of light with distance from the source
C the heating of surfaces when exposed to light
D pressure of light

Questions 14-16 refer to the following information:

The diagram below represents the wavefronts at the interface of two different media. The distance between the wavefronts in the two media are shown.



14 What is the refractive index of medium 2 with respect to medium 1?

- A $\frac{4}{6}$ C 1
B $\frac{6}{4}$ D Neither A nor B nor C as it cannot be calculated from the information given.

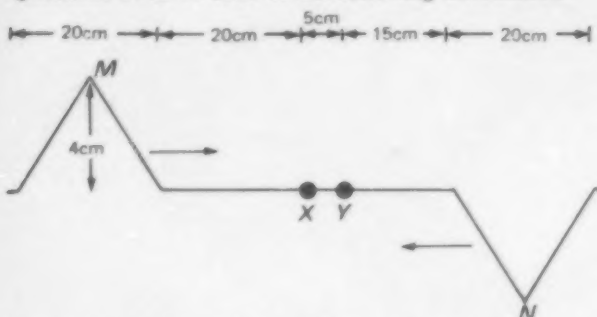
15 If the velocity of the wave in medium 1 is 60 cm s^{-1} , what is the frequency of the wave?

- A 360 s^{-1} C 10 s^{-1}
B 60 s^{-1} D 0.1 s^{-1}

16 What is the velocity of the wave in medium 2?

- A 240 cm s^{-1} C 40 cm s^{-1}
B 60 cm s^{-1} D 4 cm s^{-1}

Questions 17 & 18 refer to the following information:



Two triangular-shaped pulses, identical in shape but opposite in displacement travel toward each other along a rope. The length of the displaced portion of each pulse is 20 cm, and the points of maximum displacement, M and N, are each 10 cm from the leading edge of their respective pulses. M and N are each displaced 4.0 cm from the rest position of the rope.

17 Point X is midway between the pulses. As the pulses pass through X, what is the maximum displacement which X will undergo relative to its rest position?

- A 0 cm C 4.0 cm
B 2.0 cm D 8.0 cm

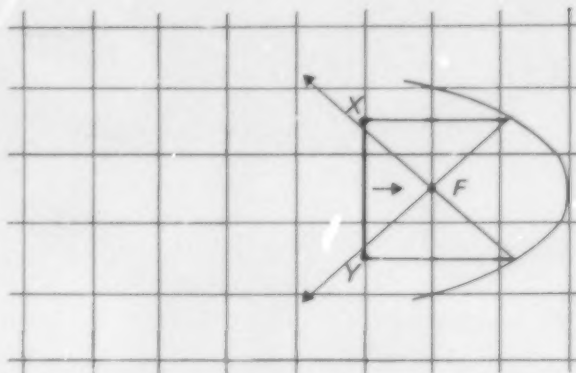
18 What will be the maximum displacement from its rest position which point Y will undergo during the passage of these two pulses?

- A 0 cm C 4.0 cm
B 2.0 cm D 8.0 cm

19 Stationary waves on a string may have

- A one frequency only.
B two frequencies only.
C a continuous range of frequencies.
D a discrete number of frequencies.

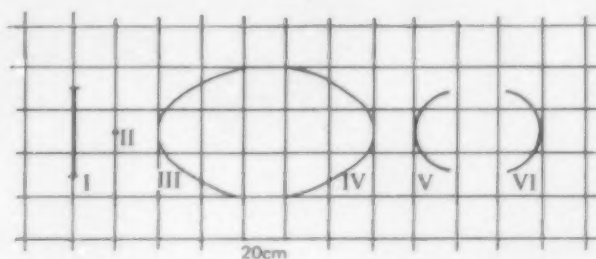
Questions 20-22 refer to the following diagram:



The diagram shows a parabolic reflector in a ripple tank. The focus of the parabola is at F. A straight pulse XY is at the position shown at time $t = 0 \text{ sec}$ and moving to the right as indicated. Waves in the ripple tank travel at 20 cm s^{-1} . The grid spacing in the diagram represents 20 cm.

Questions 20-22 and the following key refer to the shape and extent of the reflected pulse at different times after reflection.

Key



20 Which diagram best describes the reflected pulse at time $t = 4 \text{ s}$?

- A III C V
B IV D VI

21 Which diagram best describes the reflected pulse at time $t = 5 \text{ s}$?

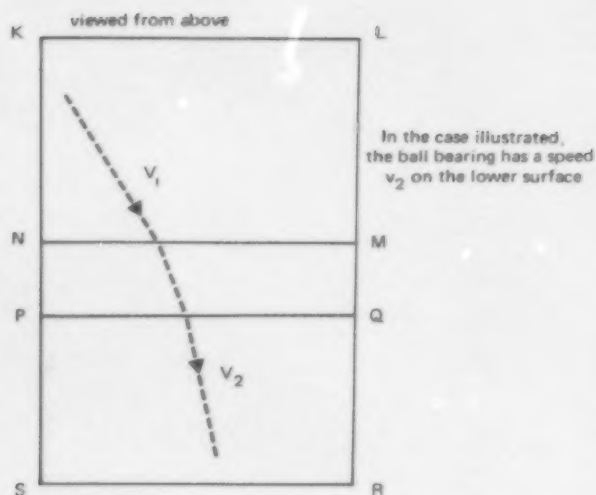
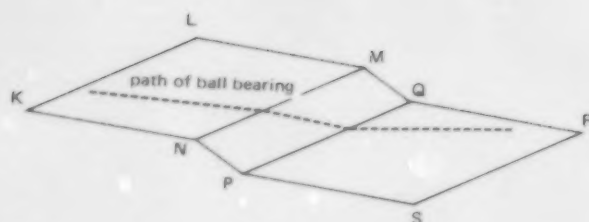
- A I C V
B II D VI

22 Which diagram best describes the reflected pulse at time $t = 6 \text{ s}$?

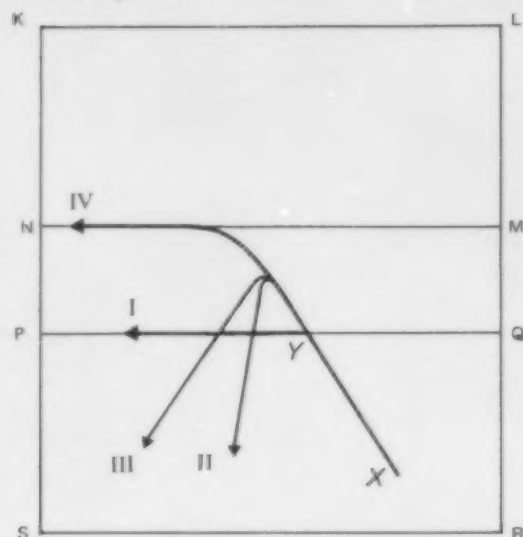
- A III C V
B IV D VI

Questions 23-25 refer to the following information:

In an experiment investigating aspects of the particle model of light, a student rolls a ball bearing along a horizontal surface $KLMN$ at constant speed v_1 . It then moves down an incline to a lower horizontal surface $PQRS$. (neglect frictional effects)



- 23 The student now rolls the ball on surface $PQRS$ along the path XY as shown below. The ball 'totally internally reflects'.



Which of the paths on the diagram best represents the path of the ball in this case?

- A path I C path III
B path II D path IV

- 24 The refractive index of the surface $KLMN$ with respect to surface $PQRS$ can be calculated from measurements of angles of incidence and refraction. If the surface $KLMN$ is now raised so that the incline is steeper, what effect will this have on the measured value of the refractive index?

It will

- A be increased.
B be decreased.
C remain the same.
D either be A or B or C depending on the values of angles of incidence used.

- 25 The student now compares results from this particle model with the behaviour of a ray of light travelling from air to water.

What feature of the particle model best corresponds to the air-water interface?

- A the surface $KLMN$ C the edge PQ
B the edge NM D the incline $NMQP$

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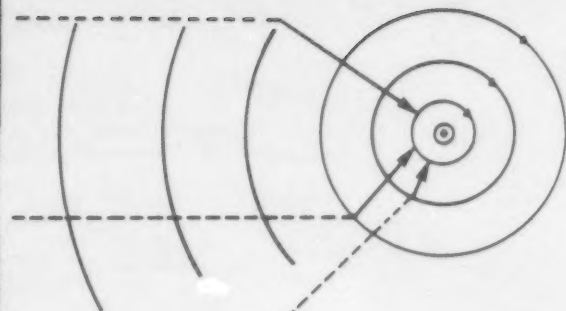
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Test 14

Kinetic theory of gases

Directions

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$$\cos 30^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

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$$\tan 30^\circ = \frac{1}{\sqrt{3}} = 0.58.$$

$$\tan 45^\circ = 1$$

$$\tan 60^\circ = \sqrt{3} = 1.73$$

- 3 Unless otherwise instructed, neglect air resistance.

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NOW TURN THE PAGE AND GO ON WITH THE TEST

1 A cylindrical vessel closed by a piston contains a constant mass of gas, whose volume is reduced to a quarter of its initial value by a movement of the piston. The temperature is maintained at a fixed value. For the average kinetic energy of a molecule, what is the value of the ratio

$$\frac{\text{Final Kinetic Energy}}{\text{Initial Kinetic Energy}}?$$

A $\frac{4}{1}$

C $\frac{1}{1}$

B $\frac{2}{1}$

D $\frac{1}{4}$

- 2 A gas in a container of volume 3 litres has its pressure doubled and its absolute temperature increased by a factor of $\frac{4}{3}$.

Its new volume will be

A $\frac{9}{8}$ litres.

C $\frac{9}{2}$ litres.

B 2 litres.

D 8 litres.

- 3 A balloon is inflated by an ideal gas to a volume of 0.25 litre. The temperature of the gas is 27°C and its pressure is $9 \times 10^4 \text{ N m}^{-2}$. What is the volume of the balloon if the temperature of the gas is changed to -3°C , and its pressure increased to $1 \times 10^5 \text{ N m}^{-2}$?

A 0.20 L

C 0.25 L

B 0.23 L

D 0.28 L

- 4 Two containers X and Y hold the same mass of the same gas at the same pressure. The temperature of the gas in Y is 400°K , while the temperature of the gas in X is 100°K . The ratio of the number of molecules in Y to the number of molecules in X is

A $\frac{1}{4}$

C $\frac{4}{1}$

B $\frac{1}{1}$

D neither A nor B nor C.

- 5 Which one of the following is *not* a basic assumption of the kinetic molecular theory of gases?

A Gases are composed of very many small particles.

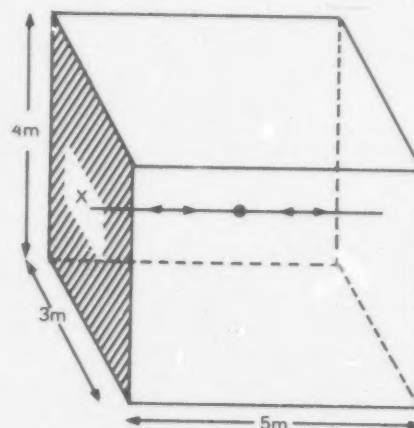
B Each molecule of the gas moves very rapidly along predetermined paths.

C The collisions between the molecules are elastic.

D The intermolecular forces are negligibly small.

Questions 6-10 refer to the following information:

A closed rectangular box has ends 3 m by 4 m, with 5 m between the ends, as shown in the diagram. A ball of mass 0.2 kg travels between the ends at 30 m s^{-1} , rebounding each time without any energy loss. The effects of gravity can be ignored.



- 6 How many times does the ball hit end X per second?

A 1

C 3

B 2

D 4

- 7 What is the magnitude of the change of momentum per second at end X?

A 6 kg m s^{-1}

C 18 kg m s^{-1}

B 12 kg m s^{-1}

D 36 kg m s^{-1}

- 8 What is the average force exerted by the ball on end X?

A 6 N

C 18 N

B 12 N

D 36 N

- 9 Suppose that there are 100 identical balls instead of just one, all travelling between the ends of the box. What would the average force on end X then become?

A 600 N

C 1800 N

B 1200 N

D 3600 N

- 10 With 100 identical balls travelling between the ends, what is the pressure exerted on end X?

A 300 Pa

C 100 Pa

B 150 Pa

D 50 Pa

- 11 To the extent that real gases approximate the behaviour of an ideal gas, they do so because their molecules

A are nearly elastic.

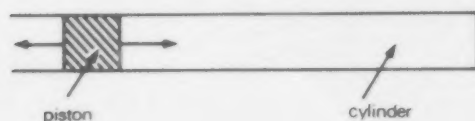
B exert attractive forces on each other.

C are widely spaced.

D take up no volume.

Questions 12-14 refer to the following information:

A quantity of ideal gas is trapped in a cylinder. The piston is free to move so that the pressure of the gas in the cylinder is always equal to the atmospheric pressure.



The temperature of the cylinder and gas are varied and the volume of the gas recorded at convenient intervals of temperature.

T °C	V (L)
20	0.50
50	0.55
100	0.64

12 The volume of 0 °C is closest to

- A 0.50 litre. C 0.40 litre.
B 0.47 litre. D zero.

13 The volume of the gas at 200 °C is closest to

- A 2.20 litres. C 0.81 litre.
B 1.28 litres. D 0.64 litre.

14 The temperature at which the volume of the gas will be 0.25 litre is

- A 10 °C. C -273 °C.
B -126.5 °C. D unable to be determined from the data given.

15 A student used the apparatus in Figure 1 to determine the relationship between pressure and volume for a sample of gas at room temperature.

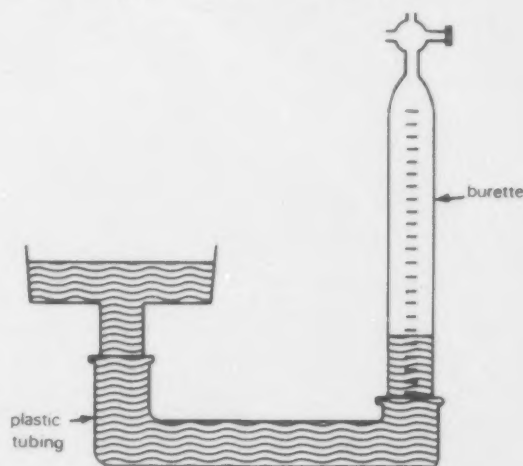


Figure 1

The results were plotted on the graph of pressure against $\frac{1}{\text{volume}}$, as shown in Figure 2.

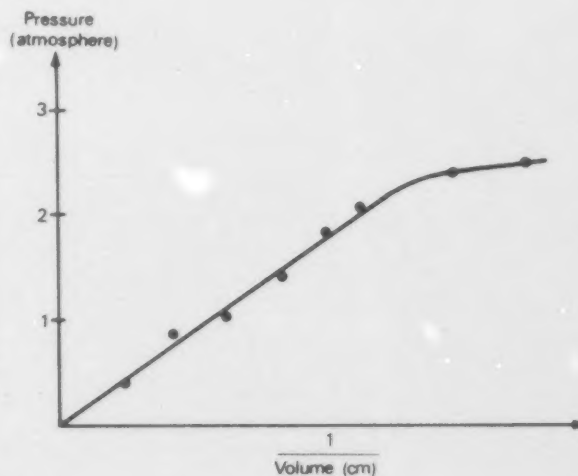
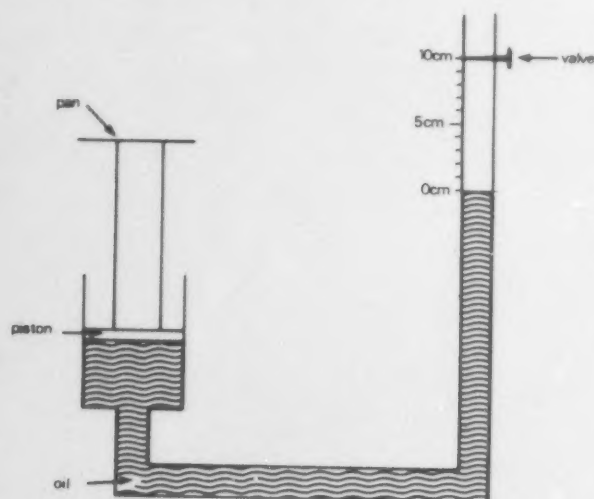


Figure 2

The student concludes that $P \propto \frac{1}{V}$ applies *only* for pressures up to 2 atmospheres. Which of the following statements is justified in view of the above information?

- A The student's conclusion is perfectly valid.
B The student should try plotting P against $\frac{1}{V^2}$.
C The student should check whether his apparatus has not sprung a leak at about 2 atmospheres pressure.
D The student should plot P against V .

Questions 16-18 refer to the following information:
The diagram shows a piston connected to a graduated cylinder.



When no mass is on the pan and the valve is open, the system balances with the oil level at the 0-centimetre mark. All effects due to friction, leakage, and the weight of the oil can be neglected. In each of three experiments, atmospheric pressure was one atmosphere and the temperature of the apparatus was 300 °K when the valve was closed with the oil at the 0-centimetre mark.

- 16 In the first experiment, the valve was closed and masses were placed on the pan raising the oil level to the 8-centimetre mark. If the temperature was held constant at 300 °K, what would be the pressure on the trapped air?

A $\frac{1}{5}$ atmosphere C 4 atmospheres
B $\frac{1}{2}$ atmosphere D 5 atmospheres

- 17 In the second experiment, the entire apparatus was heated to 400 °K after the valve was closed. If the oil level was kept at the 0-centimetre mark by adding weights to the pan, what would be the pressure on the trapped air?

A $\frac{3}{4}$ atmosphere C $\frac{4}{3}$ atmospheres
B 1 atmosphere D 2 atmospheres

- 18 In the third experiment, with the valve closed the apparatus was then cooled to 200 °K and masses were added to the pan. If the oil level rose to the 7-centimetre mark, what would be the pressure, in atmospheres, on the trapped air?

A $1 \times \frac{2}{3} \times \frac{10}{3}$ C $1 \times \frac{3}{2} \times \frac{10}{3}$
B $1 \times \frac{2}{3} \times \frac{3}{10}$ D $1 \times \frac{3}{2} \times \frac{3}{10}$

- 19 If two different gases are at the same temperature, then

A the average speeds of the molecules of the two gases are the same.
B the average kinetic energy of the molecules of the two gases are equal.
C the root mean square velocities for the molecules of the two gases are the same.
D the same number of particles are in each sample of gas.

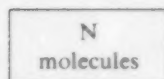
- 20 The pressure on a fixed mass of gas is halved and its absolute temperature increased by a factor of 1.5.

The new volume will be

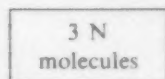
A original volume $\times 2 \times 1.5$.
B original volume $\times \frac{2}{1.5}$.
C original volume $\times \frac{1.5}{2}$.
D original volume $\times \frac{1}{2 \times 1.5}$.

Questions 21-25 refer to the following information:

Container X holds N molecules of a certain gas at atmospheric pressure. Container Y has the same volume and surface area as X and holds $3N$ molecules of the same gas as shown in the diagram. The containers are at the same temperature.



CONTAINER X



CONTAINER Y

The following key should be used in answering Questions 21-25.

KEY

A $\frac{1}{1}$

C $\frac{1}{\sqrt{3}}$

B $\frac{1}{3}$

D $\frac{3}{1}$

E $\frac{27}{1}$

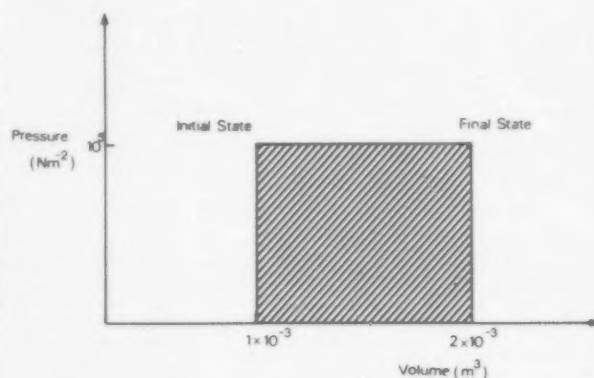
- 21 What is the ratio of the density of the gas in Y to the density of the gas in X?
- 22 What is the ratio of the average molecular speed in Y to that in X?
- 23 What is the ratio of the average force per collision with the walls in Y to the average force per collision in X?
- 24 What is the ratio of the average number of collisions per second with the walls in Y to the average number in X?
- 25 What is the ratio of the gas pressure in Y to the gas pressure in X?

Questions 26 & 27 refer to the following information:

A sample of ideal gas is contained in a cylinder by a piston of area 10^{-2} m^2 . The gas was initially at a temperature of 300°K , and at the pressure of air in the laboratory, which is 10^5 N m^{-2} . The volume of the gas was 10^{-3} m^3 .

The sample of gas was heated and allowed to expand so that its pressure remained constant until its volume was $2 \times 10^{-3} \text{ m}^3$.

The process is represented on the following pressure-volume graph.



- 26 What was the final temperature of the gas?
 A 600°K . C 300°K .
 B 450°K . D 150°K .
- 27 The physical quantity represented by the shaded area on the graph is
 A the force exerted by the piston.
 B the work done by the expanding gas.
 C the temperature rise of the gas.
 D the change in volume of the gas.

Questions 28 & 29 refer to the following information:
Four moles of argon molecules are added to a vessel containing one mole of helium molecules. The volume of the vessel and the temperature remain unchanged.

- 28 The ratio of the pressure exerted by the argon molecules to the pressure exerted by the helium molecules will be

A $\frac{1}{4}$.

C $\frac{4}{1}$.

B $\frac{1}{1}$.

D $\frac{5}{1}$.

- 29 After the introduction of the argon molecules, the pressure exerted on the walls by the helium molecules will be

A one-fifth the original pressure.

B one-fourth the original pressure.

C the same as the original pressure.

D four times the original pressure.

E five times the original pressure.

- 30 A motor car tyre contains air at a temperature of 27°C , and its pressure is 2 atmospheres (twice normal atmospheric pressure).

After a long drive on a hot day, the tyre pressure is observed to be $2\frac{1}{3}$ atmospheres.

Assuming the volume of the tyre does not change, what will be the temperature of the air in the tyre?

A 23°C .

C 54°C .

B 31.5°C .

D 77°C .

ACER PHYSICS UNIT TESTS

The ACER Physics Tests consist of the following publications.

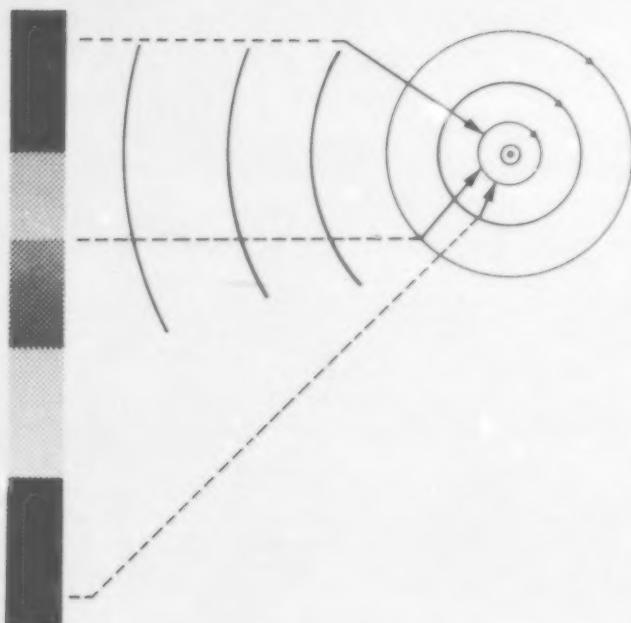
I A series of tests covering the following topics

- 1 Physical measurement*
- 2 Vectors*
- 3 Motion in one dimension*
- 4 Motion on a plane*
- 5 Dynamics*
- 6 Work and energy*
- 7 Linear momentum*
- 8 Oscillations*
- 9 Gravity and Kepler's laws*
- 10 Waves*
- 11 Light — reflection and refraction*
- 12 Light — interference, diffraction and spectra*
- 13 Models of light*
- 14 Kinetic theory of gases*
- 15 Static charges*
- 16 Electric field and potential difference*
- 17 Current electricity*
- 18 The magnetic field*
- 19 Induced EMF*
- 20 Atomic physics*
- 21 Quantum physics*

II Teachers Information Booklet

III List of Answers Booklet

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Test 15 Static charges

Directions

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- 1 Take the acceleration due to gravity, g as 10 m s^{-2} .
- 2 Where required by the calculations, take

$$\sin 30^\circ = \frac{1}{2} = 0.50.$$

$$\sin 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\sin 60^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

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$$\cos 60^\circ = \frac{1}{2} = 0.50.$$

$$\tan 30^\circ = \frac{1}{\sqrt{3}} = 0.58.$$

$$\tan 45^\circ = 1$$

$$\tan 60^\circ = \sqrt{3} = 1.73$$

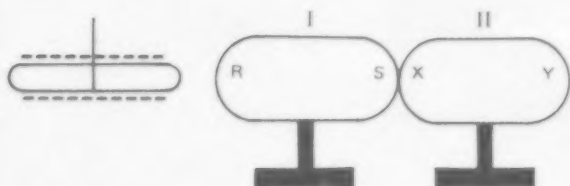
3. Unless otherwise instructed, neglect air resistance.

Jottings and calculations should be done on a separate sheet of paper.

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- 1 A non-conductor of electricity is a material
 A which contains no electrons.
 B which cannot be melted.
 C which always has more electrons than protons on its surface.
 D through which electrons do not flow freely.

Questions 2-7 refer to the following information:



A negatively charged conducting rod is suspended close to, but does not touch, two insulated conductors which are in contact. Both conductors are initially uncharged.

- 2 At R there will be an excess of
 A positive charges.
 B negative charges.
 C neither charge.
- 3 At Y there will be an excess of
 A positive charges.
 B negative charges.
 C neither charge.

Questions 4 and 5 refer to the following additional information:

While the rod remains in place conductor II is separated from conductor I by pushing on the insulated base of II. The rod is then removed.

- 4 Body I will be
 A positively charged.
 B negatively charged.
 C neutral.
- 5 Body II will be
 A positively charged.
 B negatively charged.
 C neutral.

Questions 6 and 7 refer to the following additional information:

Assume that the negatively charged rod originally touched point R while bodies I and II were in contact. If the conductors are again separated as before:

- 6 Body I will be
 A neutral.
 B positively charged.
 C negatively charged.

- 7 Body II will be
 A neutral.
 B positively charged.
 C negatively charged.

- 8 Two pith balls are charged and brought near one another. They are observed to be strongly repelled by each other. When a rod, known to have an excess of positive charges, is brought near one of the pith balls it repels the ball. Which one of the following explains the charge on the other ball?

- A There must be an excess of negative charges.
 B There must be an excess of positive charges.
 C There must be an excess of charges but there is insufficient data to determine which charge.
 D There can be no excess of charges (i.e. the ball is neutral).

- 9 Two pith balls are charged and brought close together. They are observed to be attracted by each other but not allowed to touch. When a metal rod is brought near one of the pith balls it attracts the ball.

Which of the following explains the charge on the other ball?

- A There must be an excess of negative charges.
 B There must be an excess of positive charges.
 C There must be an excess of charges but there is insufficient data to determine which charge.
 D There can be no excess of charge (i.e. the ball is neutral).

Questions 10-15 refer to the following information:

The following key should be used to indicate which description of the leaves of a gold leaf electroscope (GLE) applies in each situation.

Key A The leaves diverge because they are positively charged.

B The leaves diverge because they are negatively charged.

C The leaves remain collapsed.

D The divergence of the leaves increases.

E The divergence of the leaves decreases.

H The divergence of the leaves is unchanged.

J The divergence of the leaves increases then decreases.

K The divergence of the leaves decreases then increases.

10 A positively charged insulator is brought close to the cap of an uncharged GLE.

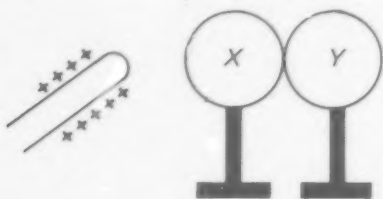
11 A negatively charged rubber rod is brought near to, but does not touch, the cap of an uncharged GLE.

12 The leaves of a GLE are negatively charged and a body with a very strong negative charge is brought close to the cap.

13 The leaves of a GLE carry a very strong positive charge and a body with a weak negative charge is brought close to the cap.

Questions 14 & 15 refer to the following additional information:

A rod with a very strong positive charge is brought close to two identical uncharged metal spheres (X and Y) on insulating stands, while the spheres are in contact.



14 Sphere X is separated from sphere Y by pushing on the insulated base of sphere Y while the charged rod is held near the spheres. Sphere Y is now brought very close to the cap of a GLE, the leaves of which carry a weak negative charge.

15 With sphere Y close to the cap of the negatively charged GLE, sphere X is brought slowly up to sphere Y, by pushing on the insulated base of sphere X, until it is touching sphere Y; however neither X nor Y touches the cap of the GLE.

16 A charge transferred to one end of a rod made from a certain material rapidly distributes itself over the whole surface of the rod.

Based on this information it can be stated that the material is

A probably an insulator.

B probably a conductor.

C either an insulator or a conductor, as there is insufficient information to decide.

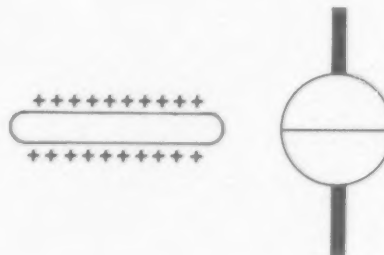
17 A certain rod is not composed of metallic material. Based on this information, it can be stated that the material of the rod is

A probably an insulator.

B probably a conductor.

C either an insulator or a conductor, as there is insufficient information to decide.

18 A positively charged rod is held near two neutral hemispheres which are initially touching. While the rod is still in position the hemispheres are separated.



Which of the following best describes the distribution of charges on the hemispheres, after the rod is removed?

A one hemisphere positive, one negative

B both hemispheres positive

C both hemispheres negative

D both hemispheres neutral

19 A copper rod held in the hand is rubbed with a piece of fur, then tested for static charges. The rod is found to be uncharged because

A charges produced on the rod by the rubbing are conducted away through the human body.

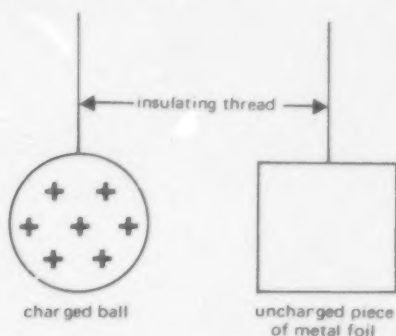
B when copper is rubbed with fur no charge is produced.

C any charge produced is too small to be detected.

D in this case charge is transferred from the rod to the fur, but not from the fur to the rod.

Questions 20 & 21 refer to the following additional information:

A charged ball and an uncharged piece of metal foil are suspended by insulating threads.



The charged ball attracts the metal foil.

20 The effect of the ball on the piece of metal foil is attributable to the fact that

- A** positive charge is transferred from the ball to the metal foil.
- B** negative charge is transferred from the metal foil to the ball.
- C** the charged ball can only influence a body which has a net neutral charge.
- D** the presence of the ball alters the distribution of charge in the metal foil.

21



Hollow metal hemispheres shown in the diagram can be placed so as to encase either the charged ball or the uncharged piece of metal foil.

The force between the ball and the metal foil will be zero

- A** only if the ball is enclosed by the hemispheres.
- B** only if the metal foil is enclosed by the hemispheres.
- C** in both cases.
- D** in neither case.

22 A polythene rod becomes negatively charged when rubbed with flannel.

The reason is that the rod

- A** gains electrons only.
- B** loses protons only.
- C** gains electrons and loses protons.

23 A sphere suspended by an insulating thread is attracted by a charged object.

Which one of the following can be stated with certainty?

- A** The sphere has a net opposite charge to that of the object.
- B** The sphere has acquired a net opposite charge by induction.
- C** The sphere is a good conductor and has a net opposite charge.
- D** Neither **A** nor **B** nor **C** can be concluded with certainty.

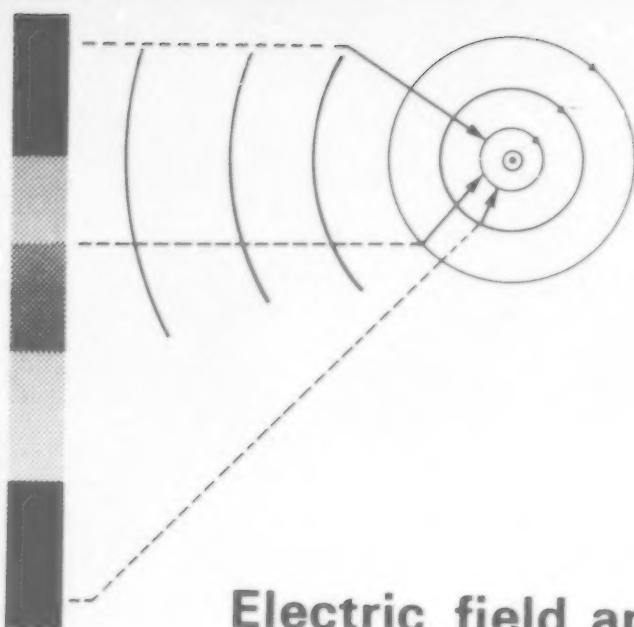
24 A negatively charged rod is brought near to, but does not touch, the cap of an uncharged GLE. The GLE is then earthed by touching the cap with a finger. The finger is removed.

If the negatively charged rod is now removed, the GLE results in having

- A** a positive charge.
- B** a negative charge.
- C** no charge.

25 The slow collapse of the leaves of a negatively charged electroscope is most likely to result from the transfer of

- A** positive charges from the ions in the air to the cap.
- B** electrons from the cap to neutral air molecules.
- C** electrons from negative ions in the air to the cap.
- D** electrons from the cap to positive ions in the air.



Test 16

Electric field and potential difference

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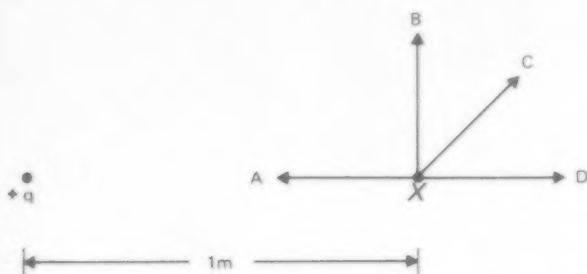
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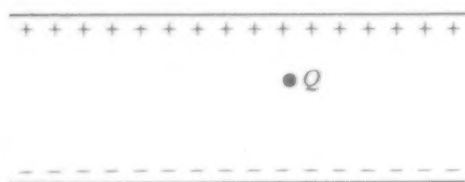
- 1 A positive charge of $+q$ coulomb is located in space. A point X is positioned 1 m from the charge. Arrows A, B, C and D represent four possible directions of the electric field at X .



Which arrow correctly represents the direction of the electric field at X ?

- 2 The electric potential at a point 0.20 m from a point charge is 1.8×10^4 V. At a point 0.30 m from this charge, the potential would be
 A 8.0×10^3 V. C 1.8×10^4 V.
 B 1.2×10^4 V. D 2.7×10^4 V.

- 3 The electric field at a point midway between two oppositely-charged, parallel conducting plates is 2×10^3 N C $^{-1}$. A point Q is at a distance of one-third of the plate separation from the positive plate.



What is the magnitude of the electric field at point Q ?

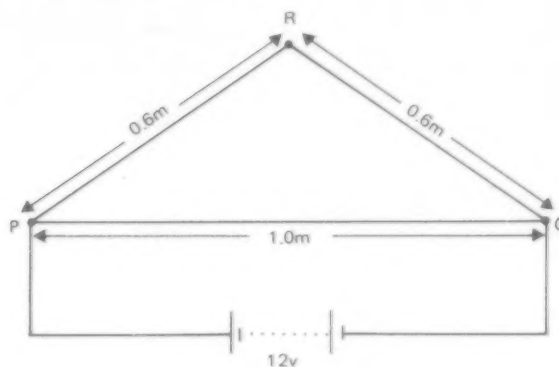
- A $\frac{2}{3} \times 10^3$ N C $^{-1}$ C $\frac{4}{3} \times 10^3$ N C $^{-1}$
 B 1×10^3 N C $^{-1}$ D 2×10^3 N C $^{-1}$
- 4 The electric force on a charge 2 m from a point charge of 2×10^{-6} C is 9×10^{-14} N. What would be the electric force if the charge separation was increased to 3 m?
 A 4×10^{-14} N C 9×10^{-14} N
 B 6×10^{-14} N D 12×10^{-14} N

- 5 A potential difference of 2500 V is applied across two parallel conducting plates with a separation of 0.05 m in a vacuum. The work done when a charge of 8.0×10^{-19} C is transferred from the positive plate to the negative plate is

A 4×10^{-17} J. C 2×10^{-15} J.
 B 1.6×10^{-17} J. D zero.

Questions 6–11 refer to the following information:

Three lengths of uniform wire cut from the same roll are connected as shown.



The potential difference between P and Q is 12 volts.

- 6 How much energy is required to move 1 coulomb of charge from P to Q via R ?

A 6 J C 12 J
 B 10 J D 14.4 J

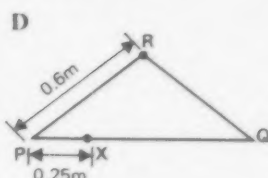
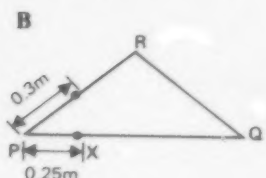
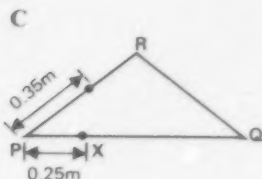
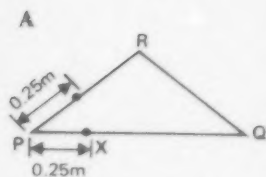
- 7 At what distance from P along PQ is the point with potential the same as that at R ?

A 0.25 m C 0.75 m
 B 0.50 m D 1.00 m

- 8 If an additional wire is connected between R and the point on PQ with potential equal to that at R , how much net charge will move along the additional wire each second?

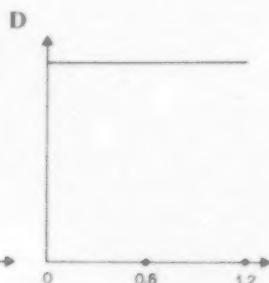
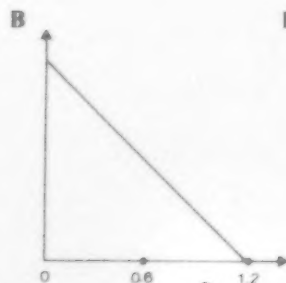
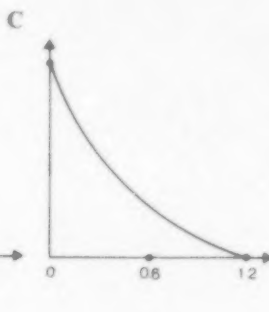
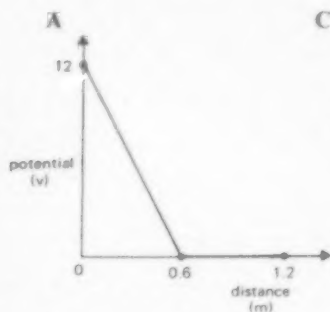
A zero C 12 C
 B 6 C D unable to be determined unless resistance of wire is known

- 9 The diagrams show four points along PRQ and a point X , 0.25 m along PQ from P .

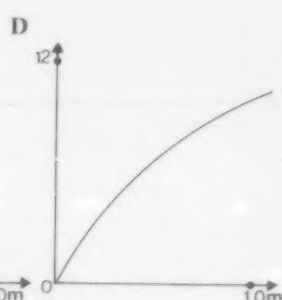
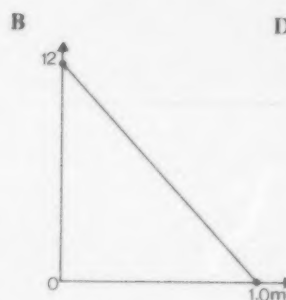
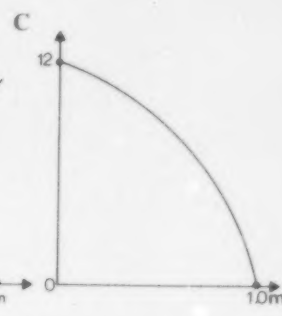
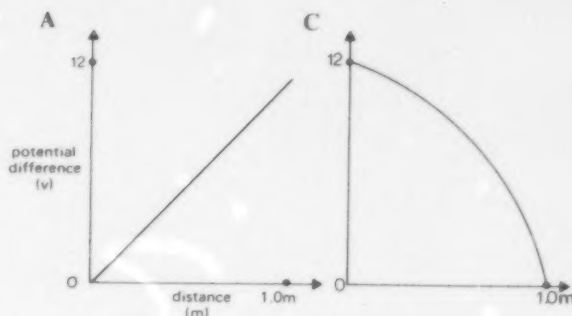


Which diagram indicates the point along PR which is at the same potential as the point X ?

- 10 Which one of the following graphs best represents the potential of a point on PRQ plotted against the distance of that point from P ? Take zero potential at Q .



- 11 X is a point which moves along PQ . Which of the following graphs best represents the potential differences between P and X , plotted against distance of X from P ?



Questions 12 & 13 refer to the following information:

A small charged sphere is suspended in a uniform electric field. The electric force is sufficient to balance the weight of the sphere. The charge on the sphere is 3.2×10^{-19} C and the weight of the sphere is 1.3×10^{-14} N.

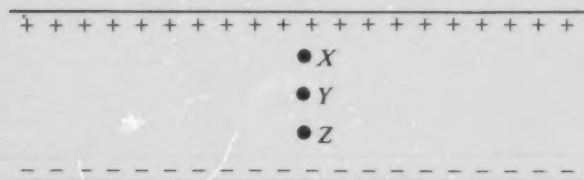
- 12 The electric field has a magnitude of
A 4.1×10^5 N C⁻¹, **C** 4.1×10^4 N C⁻¹,
B 1.3×10^5 N C⁻¹, **D** 2.5×10^{-5} N C⁻¹.

- 13 The magnitude of the charge on the sphere is changed to 4.8×10^{-19} C. A new electric field is required to balance the sphere with this new charge.

The ratio $\frac{\text{new electric field}}{\text{old electric field}}$ is

- A** $\frac{4}{9}$, **C** 1,
B $\frac{2}{3}$, **D** $\frac{3}{2}$.

- 14 An electron is located in turn at the points X , Y , and Z in the field between two long parallel charged plates as shown in the diagram.



F_X , F_Y , and F_Z are the electric forces on the electron at positions X , Y , and Z respectively.

The electric force F_Y is

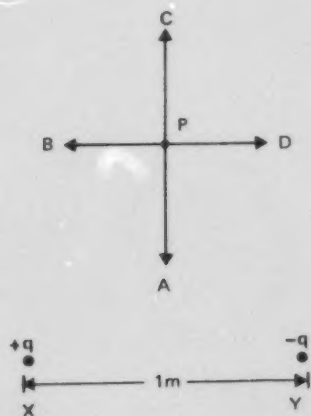
- A 0.
B greater than both F_X and F_Z .
C smaller than F_Z .
D equal to both F_X and F_Z .

- 15 An electron with a charge of 1.6×10^{-19} C and mass 9.1×10^{-31} kg is accelerated from rest by a potential difference of 10^4 V. What is the final kinetic energy of the electron?

- A 6.3×10^{22} J C 1.6×10^{-15} J
B 1.7×10^{11} J D 1.6×10^{-23} J

Questions 16–19 refer to the following information:

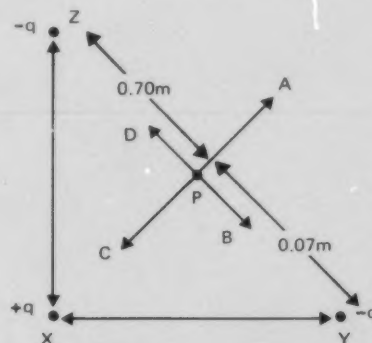
Two opposite charges of equal magnitude ($+q$ and $-q$) are placed at points X and Y 1.0 m apart. Point P is 0.70 m from each of the points X and Y .



- 16 Which of the arrows at P represents the direction of the electric field at P ?
17 If a further charge of $+q$ coulomb is placed at point P , which of the arrows A to D would now represent the direction of the net electric force acting on this charge q ?

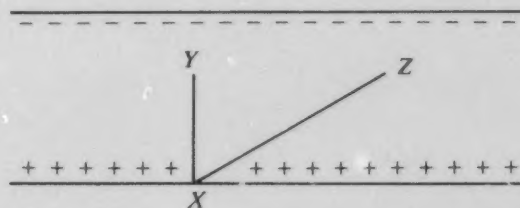
Questions 18 & 19 refer to the following additional information:

The $+q$ charge is removed from P and a third charge, identical with the charge at Y , is placed at Z . Z is 1.0 metre from X , and ZPY are in a straight line.



- 18 Which of the arrows A to D at P now represents the direction of the electric field at P ?
19 If the charges on X , Y and Z are all doubled while retaining their sign (i.e. $+2q$, $-2q$, $-2q$), which of the arrows, A to D at P , now represents the direction of the electric field at P ?

- 20 Two electrons are made to move between two parallel charged plates. The first electron moves from X to Y , the second electron from X to Z , where Y and Z are the same perpendicular distance from the positive plate.

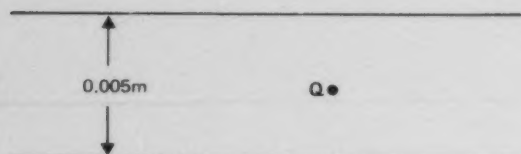


The ratio $\frac{\text{work done on first electron}}{\text{work done on second electron}}$

- A is greater than 1.
B is less than 1.
C is equal to 1.
D cannot be determined unless angle YXZ is known.

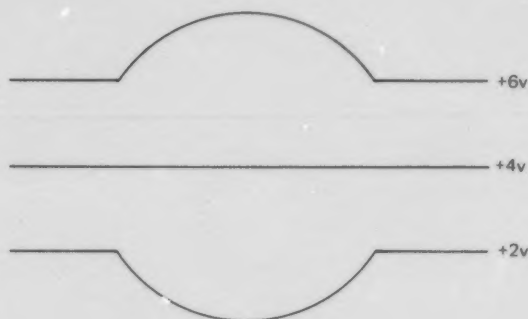
Questions 21-24 refer to the following information:

Two parallel conducting plates are separated by a distance of 0.005 m and have a potential difference applied so that a uniform electric field exists between them. A charge Q of 6.4×10^{-19} C is placed in this field.



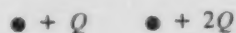
- 21 If the electrical force on the charge is 2.56×10^{-14} N, the magnitude of the electric field must be
 A 1.64×10^5 V m $^{-1}$.
 B 4.00×10^4 V m $^{-1}$.
 C 1.28×10^4 V m $^{-1}$.
 D 2.56×10^{-14} V m $^{-1}$.
- 22 The charge Q is now changed to 3.20×10^{-19} C. The electric force on this charge would be
 A 5.12×10^{-14} N.
 B 3.84×10^{-14} N.
 C 2.56×10^{-14} N.
 D 1.28×10^{-14} N.
- 23 The potential difference across the plates which would produce an electric field of 2.0×10^3 N C $^{-1}$ is
 A 4.0×10^5 V. C 1×10^{-1} V.
 B 1×10 V. D 2.5×10^{-6} V.
- 24 If the top plate is positive with respect to the bottom one, the electric force on a negatively charged body between the plates is
 A parallel to the plates and to the right.
 B parallel to the plates and into the page.
 C downwards.
 D upwards.

- 25 The following diagram is a map of some equipotential lines in an electric field.



Which properties of the electric field can be determined from the diagram?

- A the shape of the lines of force only
 B the direction of the lines of force only
 C the shape and the direction of the lines of force
 D neither the shape nor the directions of the lines of force
- 26 Two point charges of $+Q$ and $+2Q$ are placed as represented in the diagram.

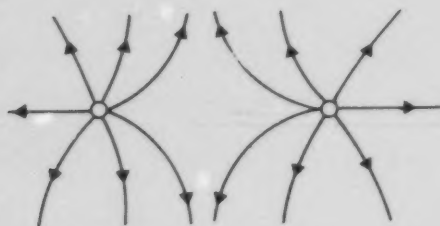


The magnitude of the electric force on the $+2Q$ charge compared with the magnitude of the electric force on the $+Q$ charge is

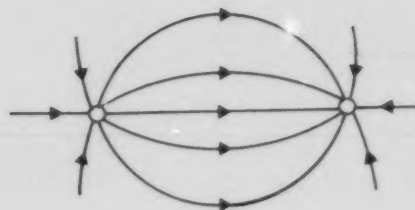
- A the same. C twice as great.
 B half the value. D four times as great.

Questions 27-29 refer to the following diagrams:

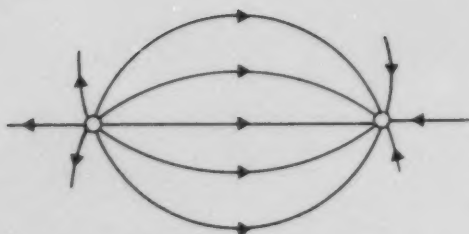
A



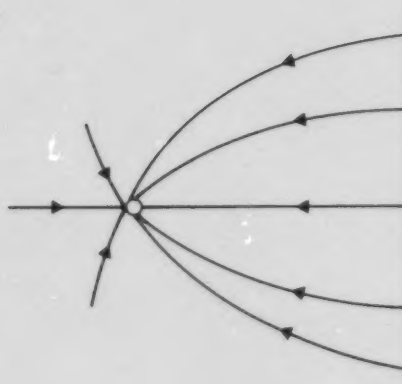
C



B



D



- 27 Which diagram could **not** represent the electric field between two charged bodies?
- 28 Which diagram represents the electric field between two bodies with like charges?
- 29 Which diagram represents a situation where there is a point in the electric field at which a negative charge would experience **no** net electrical force?

ACER PHYSICS UNIT TESTS

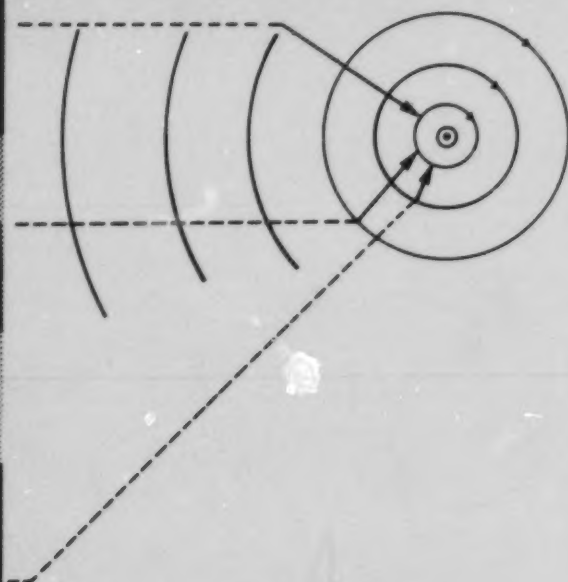
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- 10 *Waves*
- 11 *Light — reflection and refraction*
- 12 *Light — interference, diffraction and spectra*
- 13 *Models of light*
- 14 *Kinetic theory of gases*
- 15 *Static charges*
- 16 *Electric field and potential differences*
- 17 *Current electricity*
- 18 *The magnetic field*
- 19 *Induced emf*
- 20 *Atomic physics*
- 21 *Quantum physics*

II Teachers Information Booklet

III List of Answers Booklet



Test 17 Current electricity

Directions

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When answering the questions keep these points in mind:

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The following information may be useful and should always be accepted where relevant.

- 1 Take the acceleration due to gravity, g as 10 m s^{-2} .
- 2 Where required by the calculations, take

$$\sin 30^\circ = \frac{1}{2} = 0.50.$$

$$\sin 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\sin 60^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 30^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\cos 60^\circ = \frac{1}{2} = 0.50.$$

$$\tan 30^\circ = \frac{1}{\sqrt{3}} = 0.58.$$

$$\tan 45^\circ = 1$$

$$\tan 60^\circ = \sqrt{3} = 1.73$$

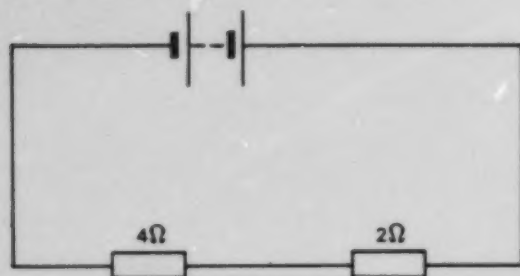
- 3 Unless otherwise instructed, neglect air resistance.

Jottings and calculations should be done on a separate sheet of paper.

Do not write on this test booklet

NOW TURN THE PAGE AND GO ON WITH THE TEST

Questions 1-3 refer to the following information:
The diagram represents the connection between a battery and two resistors.



- 1 The ratio $\frac{\text{potential difference across } 4 \text{ ohm resistor}}{\text{potential difference across } 2 \text{ ohm resistor}}$ is

A $\frac{2}{1}$ C $\frac{1}{2}$

B $\frac{1}{1}$ D unable to be determined from the information given.

- 2 The ratio $\frac{\text{current in } 4 \text{ ohm resistor}}{\text{current in } 2 \text{ ohm resistor}}$ is

A $\frac{2}{1}$ C $\frac{1}{2}$

B $\frac{1}{1}$ D unable to be determined from the information given.

- 3 The ratio $\frac{\text{power dissipated in } 4 \text{ ohm resistor}}{\text{power dissipated in } 2 \text{ ohm resistor}}$ is

A $\frac{4}{1}$ C $\frac{1}{2}$

B $\frac{2}{1}$ D $\frac{1}{4}$

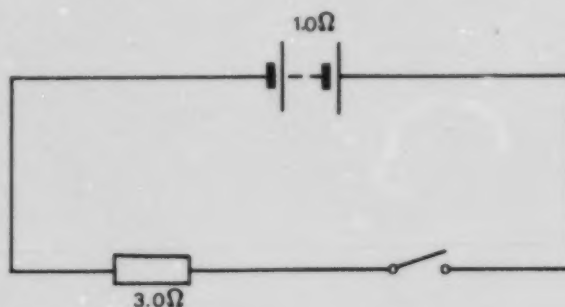
- 4 Ohm's law relates potential difference, V , across a resistor of resistance R , and the current, I , through it.

Which one of the following is a mathematical expression of Ohm's law?

A $I = \frac{V}{R}$ C $R = VI^2$

B $R = VI$ D $V = \frac{I}{R}$

Questions 5 & 6 refer to the following information:
The diagram represents the connection between a battery, a resistor, and a switch.



- 5 When the switch is closed the current through the resistor is 3.0 amperes. What is the potential difference across the resistor?

A 1 V

C 9 V

B 3 V

D 12 V

- 6 What is the emf of the battery?

A 3 V

C 10 V

B 9 V

D 12 V

- 7 What is the power dissipated by an electric light filament of resistance 2.0 ohms if a potential of 12 volts is maintained across the terminals?

A 6.0 watts

C 48 watts

B 24 watts

D 72 watts

- 8 A piece of electrical resistance wire, of length 50 cm and uniform cross-section, is joined in series with a milliammeter and a battery, both with negligible internal resistance. The meter reads 200 mA. If the length of the wire is increased to 80 cm, what current would be observed?

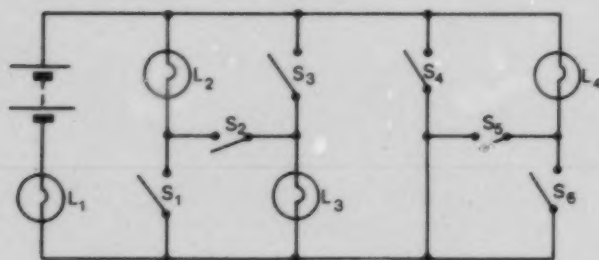
A 78 mA

C 320 mA

B 125 mA

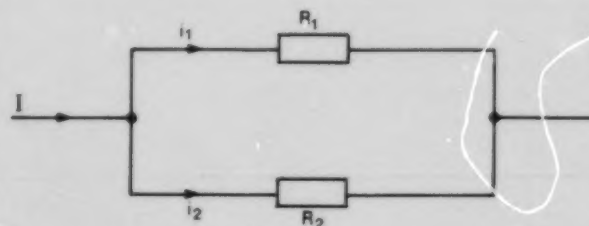
D 512 mA

Questions 9-11 refer to the following information:
A battery, 4 light globes (L_1, L_2, L_3, L_4), and 6 switches ($S_1, S_2, S_3, S_4, S_5, S_6$) are connected as shown.



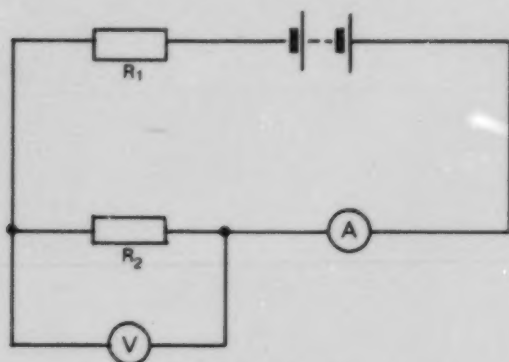
- 9 Which one of the following best describes the situation if switch S_2 only is closed?
- A L_1 only would light.
B L_1 and L_2 only would light.
C L_1, L_2 , and L_3 only would light.
D L_1, L_2, L_3 , and L_4 would light.
- 10 Which one of the following best describes the situation if switch S_5 only is closed?
- A L_4 only would light.
B L_1 and L_3 only would light.
C L_1 and L_4 only would light.
D No globes would light.
- 11 Which one of the following best describes the situation if switches S_3 and S_4 only are closed?
- A L_1 only would light.
B L_1 and L_3 only would light.
C L_2 and L_3 only would light.
D L_1, L_2, L_3 , and L_4 would light.

Questions 12 & 13 refer to the following information:
A parallel resistance network is set up as shown.

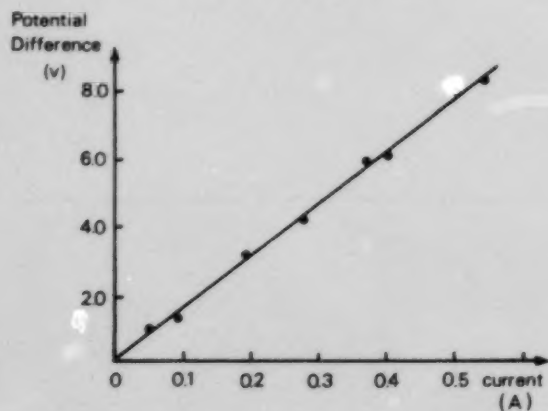


- 12 What is the mathematical relationship between I, i_1 and i_2 ?
- A $I = i_1 - i_2$ C $I = i_1 i_2$
B $I = \frac{i_1}{i_2}$ D $I = i_1 + i_2$
- 13 What is the expression for i_1 in terms of i_2, R_1 and R_2 ?
- A $i_1 = i_2 \frac{R_1}{R_2}$ C $i_1 = \frac{i_2 R_2}{R_1}$
B $i_1 = \frac{R_2}{i_2 R_1}$ D $i_1 = \frac{R_1}{i_2 R_2}$

Questions 14-16 refer to the following information:
The diagram represents a circuit containing two resistors, a voltmeter, an ammeter, and a battery.



The graph shows the relation between the current through R_2 and the potential difference across it.



- 14 Which one of the following is most nearly the current flowing through the resistor R_2 when the potential difference across it is 5.0 volt?

A 0.33 A C 2.4 A
B 0.40 A D 3.3 A

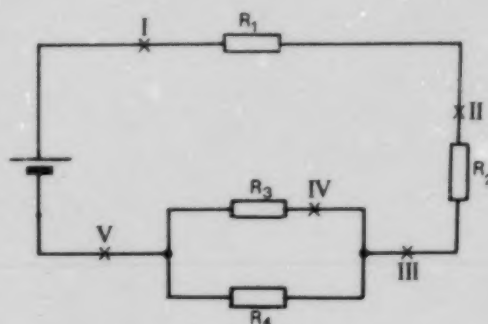
- 15 The resistance of the resistor R_2 is closest to

A 1.5 Ω . C 15 Ω .
B 1.7 Ω . D 17 Ω .

- 16 If the emf of the battery needed to supply a current of 0.40 ampere is 8.0 volt, what is the resistance of the resistor R_1 ? (Assume that the battery has negligible internal resistance.)

A 3 Ω C 18.5 Ω
B 5 Ω D 20 Ω

Questions 17-21 refer to the following information:



In the circuit diagram, resistors R_1 , R_2 , R_3 , R_4 have equal resistance and are connected by wires with resistance which may be regarded as zero.

I, II, III, IV, and V are five points in the circuit.

- 17 Which one of the following points has the smallest current passing through it?

A I C IV
B III D V

- 18 Between which pair of points is the potential difference zero?

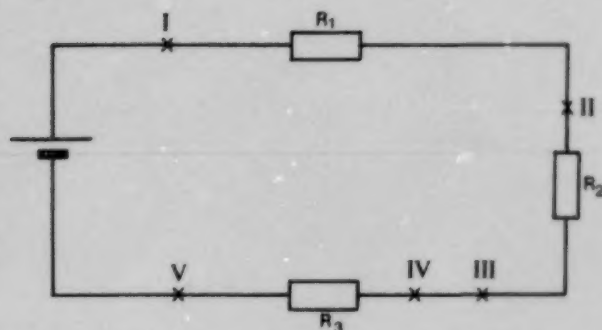
A I and V C IV and V
B III and IV D neither A, nor B, nor C

- 19 Between which of the following pairs of points is the potential difference greatest?

A I and II C III and IV
B II and III D I and V

Questions 20 & 21 refer to the following additional information:

Resistor R_4 is now removed from the circuit. The new circuit is represented in the diagram.



20 A greater current than before is now passing through

A IV only

C IV and V only

B V only

D none of the points

21 Which of the following points now have a smaller current passing through them than before?

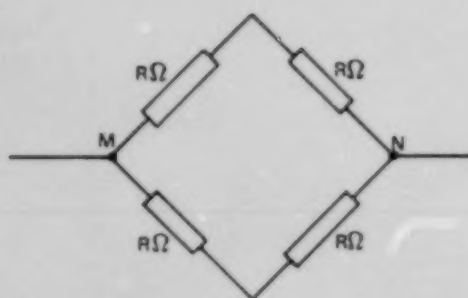
A IV and V only

B I, II, III and V only

C I, II, III, IV and V

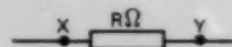
D none of the points

22 The diagram represents a section of a circuit showing the connections between four equal resistors. Each resistor has a resistance of $R \Omega$.

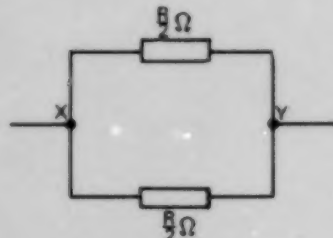


In which one of the following networks is the resistance between points X and Y equivalent to the resistance between points M and N in the above diagram?

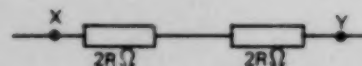
A



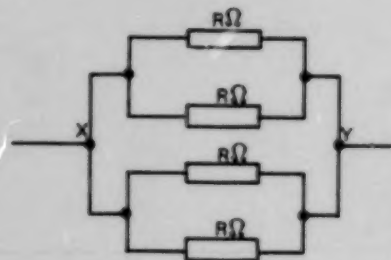
B



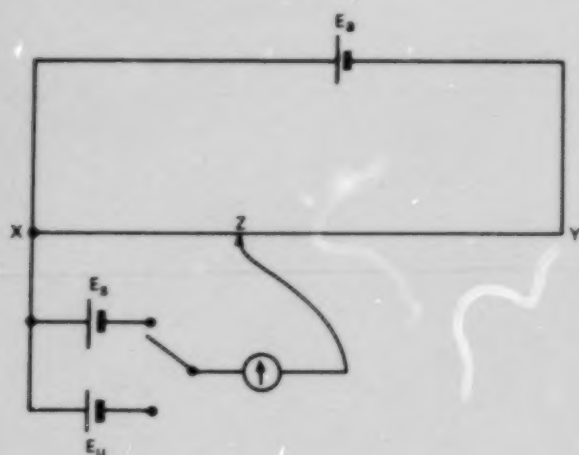
C



D



Questions 23–25 refer to the following information:
The diagram represents a circuit of a potentiometer.



The potentiometer is used basically to determine the emf of a cell.

The procedure for determining the unknown emf is as follows:

- By using a standard cell (i.e. a cell of known emf, E_s), a point Z is found such that there is no galvanometer current. Under such conditions, the potential difference across XZ because of the cell E_s is equal to the emf of the standard cell.
- The circuit is then switched to include the cell of unknown emf (E_u) and the new balance point found. The potential difference across XZ because of cell E_s is now equal to the emf of the cell E_u .
- The unknown emf is then calculated. (The current through XY is the same in both situations and, as XY is a wire of uniform thickness, the resistance of the section of wire XZ is proportional to the length of XZ.)

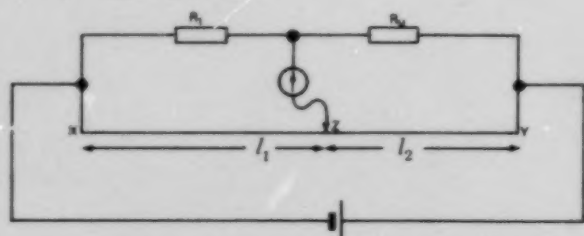
- 23 The following key lists six conditions relevant to the potentiometer.

KEY

- The emf of cell E_s is greater than the emf of cell E_u .
 - The emf of cell E_s is less than the emf of cell E_u .
 - The emf of cell E_s equals the emf of cell E_u .
 - The emf of cell E_s is greater than the emf of cell E_u .
 - The emf of cell E_s is less than the emf of cell E_u .
 - The emf of cell E_s equals the emf of cell E_u .
- Which of the above conditions must be met in order to obtain a balance point between X and Y in both situations?
- | | |
|--------------|------------|
| A I and IV | C II and V |
| B III and VI | D I and VI |

- 24 If the ratio of the lengths XZ for cells E_s and E_u is $\frac{4}{1}$ what is the ratio of the emfs of cells E_s and E_u ?
- | | |
|-----------------|-----------------|
| A $\frac{1}{4}$ | C $\frac{2}{1}$ |
| B $\frac{1}{2}$ | D $\frac{4}{1}$ |
- 25 When $E_s = 1.25$ V, a balanced point is obtained for XZ = 26 cm. What is the emf of another cell which is balanced for XZ = 52 cm?
- | | |
|---------|-----------|
| A 6.0 V | C 2.5 V |
| B 3.0 V | D 0.625 V |

Questions 26 & 27 refer to the following information:
The diagram represents a slide wire bridge circuit. The major components are: two resistors, one of known resistance (R_1) and the other of unknown resistance (R_u), a metre of wire of uniform cross-section, a galvanometer, a sliding contact (Z), and a cell.



To determine the value of the unknown resistor, the contact Z is moved along XY until the galvanometer is undeflected. When the circuit is balanced in this way, the potential difference across R_1 is equal to the potential difference across l_1 . Similarly the potential difference across R_u equals that across l_2 .

- 26 For a balance circuit, what is the value of R_u in terms of R_1 , l_1 and l_2 ?
- | | |
|-------------------------------|-------------------------------|
| A $R_u = R_1 \frac{l_1}{l_2}$ | C $R_u = l_1 + l_2 - R_1$ |
| B $R_u = l_2 - l_1 + R_2$ | D $R_u = R_1 \frac{l_2}{l_1}$ |
- 27 When R_1 is 12Ω , the galvanometer is not deflected when the sliding contact is at the 60 cm mark (i.e. $l_1 = 60$ cm and $l_2 = 40$ cm). What is the resistance of R_u ?
- | | |
|--------------|---------------|
| A 4Ω | C 18Ω |
| B 8Ω | D 32Ω |

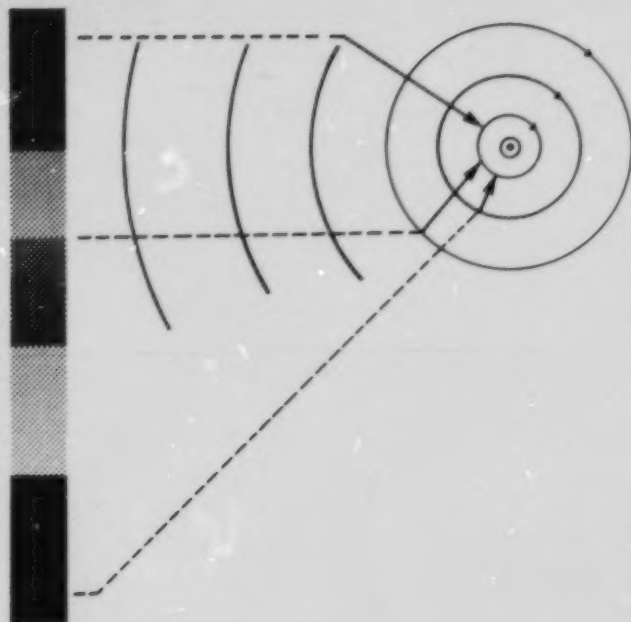
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 - 8 *Oscillations*
 - 9 *Gravity and Kepler's laws*
 - 10 *Waves*
 - 11 *Light — reflection and refraction*
 - 12 *Light — interference, diffraction and spectra*
 - 13 *Models of light*
 - 14 *Kinetic theory of gases*
 - 15 *Static charges*
 - 16 *Electric field and potential difference*
 - 17 *Current electricity*
 - 18 *The magnetic field*
 - 19 *Induced EMF*
 - 20 *Atomic physics*
 - 21 *Quantum physics*

II Teachers Information Booklet

III List of Answers Booklet



Test 18

The magnetic field

Directions

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- 1 Take the acceleration due to gravity, g as 10 m s^{-2} .
- 2 Where required by the calculations, take

$$\sin 30^\circ = \frac{1}{2} = 0.50.$$

$$\sin 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\sin 60^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 30^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\cos 60^\circ = \frac{1}{2} = 0.50.$$

$$\tan 30^\circ = \frac{1}{\sqrt{3}} = 0.58.$$

$$\tan 45^\circ = 1$$

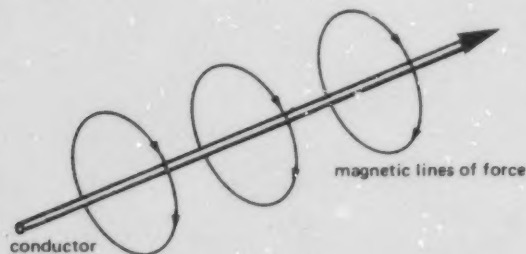
$$\tan 60^\circ = \sqrt{3} = 1.73$$

3. Unless otherwise instructed, neglect air resistance.

Jottings and calculations should be done on a separate sheet of paper.

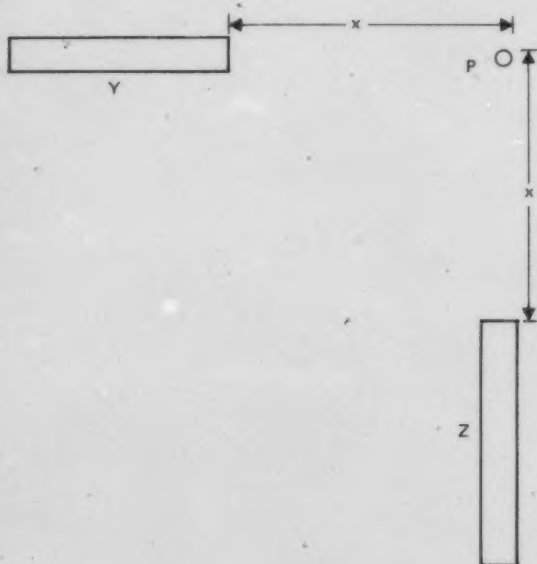
Do not write on this test booklet
NOW TURN THE PAGE AND GO ON WITH THE TEST

- 1 The diagram shows the direction of the magnetic field produced by an electric current in a conductor.



The arrowhead at the top of the conductor shows the direction of flow of

- A conventional current.
 - B electron current.
 - C either conventional or electron current: there is not enough information to decide.
- 2 If a compass needle is held a few centimetres above a wire carrying a large current in a direction from north to south, the north-seeking pole of the needle will point approximately
- A north.
 - B east.
 - C west.
 - D south.
- 3 Magnet Y initially produces a magnetic field of strength B tesla at point P . A similar magnet Z is then placed at an identical distance from P , as shown in the diagram.



The strength of the field at P must change to

- A zero.
- B $\sqrt{2}B$ tesla.
- C $2B$ tesla.
- D either $2B$ tesla or zero depending on whether like or unlike poles face P .

- 4 Two infinitely long straight wires carrying parallel currents attract each other with a known force. Which one of the following changes would reduce the force between these two wires by a half?

- A halving the distance between the wires
- B decreasing the distance between the wires by a factor of $\sqrt{2}$
- C increasing the distance between the wires by a factor of $\sqrt{2}$
- D doubling the distance between the wires

- 5 A moving charged particle experiences a force due to a magnetic field at right angles to its direction of motion. The force exerted on the particle

- A will not change the particle's speed.
- B is dependent on the square of the particle's velocity.
- C is independent of the charge of the particle.
- D is inversely proportional to the mass of the particle.

- 6 A current flowing at right angles to a magnetic field of 4×10^{-2} tesla experiences a force of 4×10^{-2} newton for every 0.1 metre of the conductor in the field.

The magnitude of the current is

- A 10A.
- B 4×10^{-1} A.
- C 4×10^{-2} A.
- D 16×10^{-3} A.

- 7 A magnetic field exerts a force upon an electric charge when the charge is

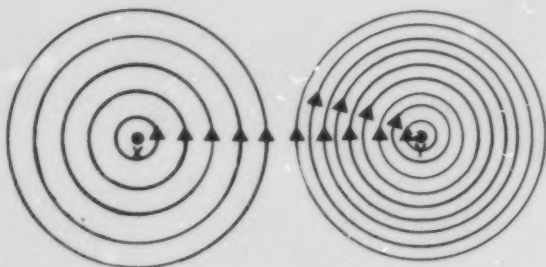
- A moving in the direction of the field only.
- B moving in the opposite direction of the field only.
- C moving across but not parallel to the field only.
- D A and B and C are all correct.

- 8 A beam of charged particles, an electric field and a magnetic field are each at right angles to one another. The electric field has a magnitude of 5×10^4 V m $^{-1}$ and the magnetic field 2×10^{-3} tesla.

If the beam is undeflected by its passage through the fields then the speed of the particles is

- A 4.0×10^7 m s $^{-1}$.
- B 2.5×10^7 m s $^{-1}$.
- C 1.0×10^2 m s $^{-1}$.
- D neither A nor B nor C, as the speed cannot be determined from the information given.

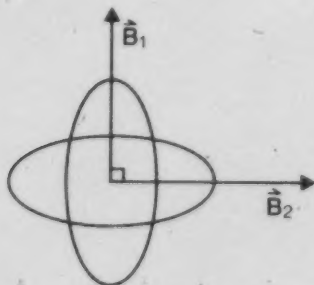
- 9 The magnetic fields associated with two current-carrying conductors is shown in the diagrams (drawn to the same scale).



Which one of the following statements regarding the currents in the two conductors is consistent with the information given?

Current X is flowing in the

- A same direction as, and is greater than, current Y .
 B same direction as, and is less than, current Y .
 C opposite direction to, and is greater than, current Y .
 D opposite direction to, and is less than, current Y .
- 10 The magnitude of the magnetic field strength 0.05 m from an infinitely long, straight conductor carrying a current is $3 \times 10^{-6} \text{ tesla}$.
 The magnetic field at a point 0.15 m from the conductor would have a field strength of
- A $9 \times 10^{-6} \text{ tesla}$. C $1 \times 10^{-6} \text{ tesla}$.
 B $3 \times 10^{-6} \text{ tesla}$. D $\frac{1}{3} \times 10^{-6} \text{ tesla}$.
- 11 Two circular wire loops have equal radii and each carries a current of 2 amperes. They are placed in such a way that they have a common centre and so their magnetic fields $\vec{B}_1$ and $\vec{B}_2$ are at right angles to each other, as shown in the diagram.

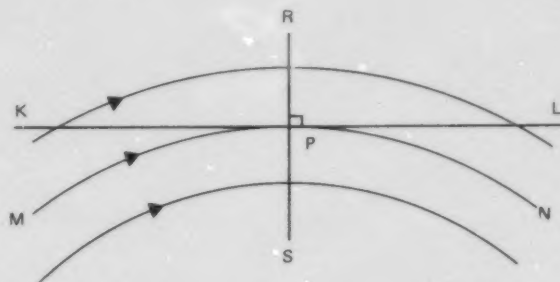


The loops are to be replaced by a single loop of the same radius which produces a magnetic field equivalent to the resultant field of the two current loops.

What is the current, in amperes, in the single loop?

- A 2 C 4
 B $2\sqrt{2}$ D 8

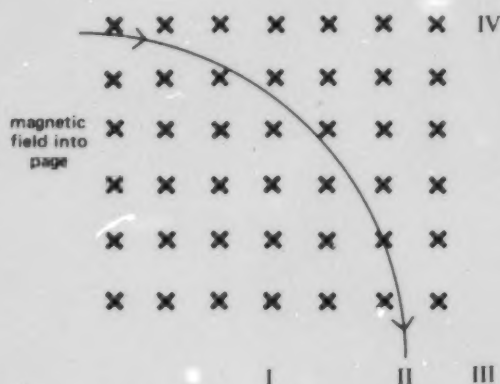
- 12 The curved lines in the diagram are magnetic field lines. KL is a tangent at P to the curve MN . RS is perpendicular to KL . KL , RS and MN are coplanar.



If a positive point charge is placed at P , it would

- A move along the curved path PN .
 B move along the curved path PM .
 C move along the path PS .
 D remain stationary.
- 13 A beam of electrons enters a uniform magnetic field at right angles to the field.
 The path of the beam in the field will be
- A circular. C helical.
 B elliptical. D parabolic.

The path of a charged particle moving at right angles to a given magnetic field is shown in the diagram.



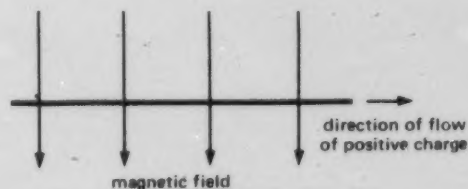
- 14 The charge on the particle
- A is positive.
 - B is negative.
 - C is neutral.
 - D cannot be determined from the information given.
- 15 If an identically charged particle of smaller mass passed through the magnetic field with the same initial velocity, its path would
- A be deflected towards I.
 - B be deflected towards III.
 - C be deflected towards IV.
 - D remain in the same direction as II.
- 16 If the speed of the particle were increased, its path would
- A be deflected towards I.
 - B be deflected towards III.
 - C be deflected towards IV.
 - D remain in the same direction as II.
- 17 If the magnitude of the magnetic field were increased, the particle would
- A be deflected towards I.
 - B be deflected towards III.
 - C be deflected towards IV.
 - D remain in the same direction as II.

1 To indicate direction, the three dimensional frame of reference should be referred to:



x - y is in the plane of the paper, and x - y - z are mutually perpendicular.

- 11 The constant used for calculating the magnetic field of a straight wire should be taken as $2 \times 10^{-7} \text{ N A}^{-2}$.
- 18 A current flows at right angles to the magnetic field as shown in the diagram.

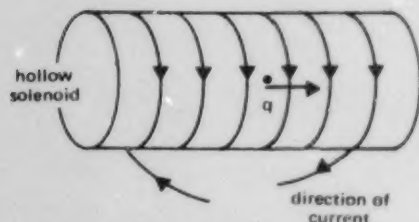


A x . **C** z .

B $-x$. **D** $-z$.

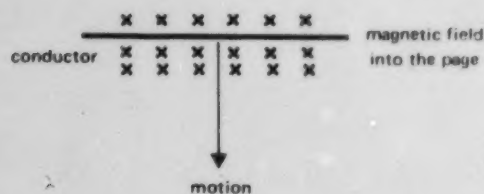
- 19** The force on a current-carrying conductor which is at right angles to a magnetic field is 1×10^{-3} newton for every 0.2 metre of conductor. The strength of the field is
- A** 2×10^{-4} tesla.
B 1×10^{-4} tesla.
C 5×10^{-5} tesla.
D neither A nor B nor C, as the strength cannot be determined from the information given.

- 20 The diagram shows a small positive charge, q , moving in the direction shown inside a hollow solenoid.



The force on q due to the magnetic field is
 A in the direction of x .
 B in the direction of y .
 C in the direction of z .
 D zero.

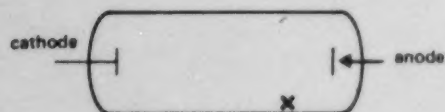
- 21 A conductor moves down through a magnetic field as represented in the diagram.



The negatively-charged particles in the conductor will experience

- A no force.
 B a force in the direction of $-x$.
 C a force in the direction of x .
 D a force in the direction of z .

- 22 When a high potential difference is applied between an anode and cathode, a stream of electrons flows between these electrodes. Under certain conditions it is possible to use a magnetic field to deflect the stream to another point X as shown in the diagram.

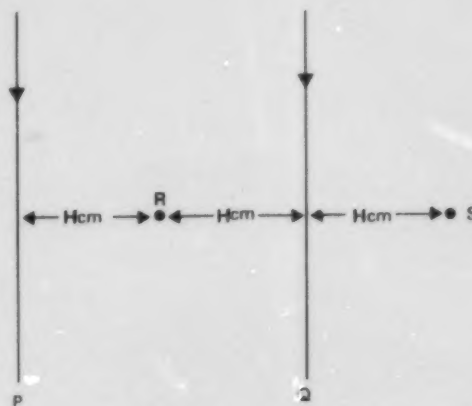


The direction of the magnetic field used to deflect the stream to X would be in the direction of

- A x .
 B $-y$.
 C $-z$.
 D z .

Questions 23-25 refer to the following information:

P and Q are parallel vertical wires carrying equal conventional currents flowing downwards. The points R and S are in the same plane as the two wires, and are equidistant from the wires as shown.



- 23 The magnetic field at S is in the direction of
 A y .
 B $-y$.
 C z .
 D $-z$.
- 24 The magnetic field at R is
 A in the direction of z .
 B in the direction of $-z$.
 C in the direction of x .
 D zero.

The following additional information is required for Question 25:

The currents in the two wires are now changed so that a current of 30 A flows in wire P and a current of 5 A flows in wire Q . Assume that the wires are 0.2 m apart and that point S is 0.1 m from wire Q .

- 25 What is the magnitude of the resultant magnetic field at S ?
 A 1×10^{-5} tesla
 B 2×10^{-5} tesla
 C 3×10^{-5} tesla
 D 4×10^{-5} tesla

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I A series of tests covering the following topics

- 1 *Physical measurement*
- 2 *Vectors*
- 3 *Motion in one dimension*
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- 5 *Dynamics*
- 6 *Work and Energy*
- 7 *Linear momentum*
- 8 *Oscillations*
- 9 *Gravity and Kepler's laws*
- 10 *Waves*
- 11 *Light — reflection and refraction*
- 12 *Light — interference, diffraction and spectra*
- 13 *Models of light*
- 14 *Kinetic theory of gases*
- 15 *Static charges*
- 16 *Electric field and potential differences*
- 17 *Current electricity*
- 18 *The magnetic field*
- 19 *Induced emf*
- 20 *Atomic physics*
- 21 *Quantum physics*

II Teachers Information Booklet

III List of Answers Booklet

Test 19 Induced EMF

Directions

This test is designed to help you discover any difficulties and misunderstandings you may have in the work that you recently studied in your physics course. It is not intended to allocate a grade or mark to you as a result of taking the test. After completing and marking the test you will be able to make your own record of the questions that you were unable to answer correctly. This record will indicate the parts of the course to which you need to give further attention immediately.

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- 2 For each question, several alternatives are given. You should choose the **best** answer from these alternatives.

The following information may be useful and should always be accepted where relevant.

- 1 Take the acceleration due to gravity, g as 10 m s^{-2} .
- 2 Where required by the calculations, take

$$\sin 30^\circ = \frac{1}{2} = 0.50.$$

$$\sin 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\sin 60^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 30^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\cos 60^\circ = \frac{1}{2} = 0.50.$$

$$\tan 30^\circ = \frac{1}{\sqrt{3}} = 0.58.$$

$$\tan 45^\circ = 1$$

$$\tan 60^\circ = \sqrt{3} = 1.73$$

- 3 Unless otherwise instructed, neglect air resistance.

Jottings and calculations should be done on a separate sheet of paper.

Do not write on this test booklet
NOW TURN THE PAGE AND GO ON WITH THE TEST

- 1 An induced EMF is produced when a bar magnet is moved into a coil. The following key lists several factors of the coil and magnet.

KEY

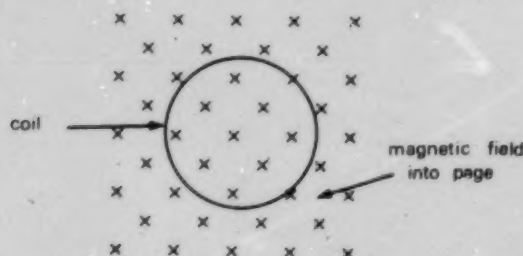
- I the temperature of the coil
- II the number of turns in the coil
- III the resistivity of the wire in the coil
- IV the speed with which the magnet is moved

On which of the following does the magnitude of the EMF depend?

- A II only
- B II and IV only
- C II, III and IV only
- D I, II, III and IV

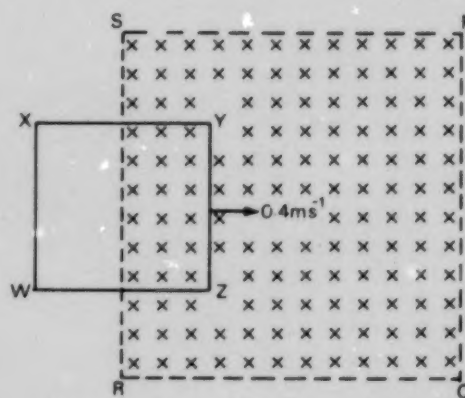
Questions 2-4 refer to the following information:

The diagram shows a coil consisting of 20 turns of conducting wire each with a cross-sectional area of $3.0 \times 10^{-2} \text{ m}^2$. It is held at right angles to a magnetic field of intensity $6.0 \times 10^{-4} \text{ tesla}$.



- 2 As the magnetic field is steadily reduced to zero over a period of $1.0 \times 10^{-2} \text{ s}$, the EMF generated in the coil would be
 - A $3.6 \times 10^{-6} \text{ V}$
 - B $1.8 \times 10^{-4} \text{ V}$
 - C $3.6 \times 10^{-2} \text{ V}$
 - D $1.0 \times 10^{-4} \text{ V}$
- 3 The magnetic field is changed from $6.0 \times 10^{-4} \text{ tesla}$ to $1.0 \times 10^{-3} \text{ tesla}$ in 2 seconds. The resulting change of flux linking each turn of the coil would be
 - A $2.4 \times 10^{-4} \text{ weber}$
 - B $1.2 \times 10^{-5} \text{ weber}$
 - C $6.0 \times 10^{-6} \text{ weber}$
 - D $3.0 \times 10^{-6} \text{ weber}$
- 4 As the magnetic field is reduced to zero, the induced conventional current would tend to flow
 - A in a clockwise direction.
 - B in an anticlockwise direction.
 - C first in a clockwise and then an anticlockwise direction (an alternating current).

Questions 5 & 6 refer to the following information:



WXYZ represents a rigid conducting loop made of metal. Each side of the loop is of length 2 cm. The square region PQRS represents the limits of a uniform field of magnetic induction $\vec{B}$ of magnitude $3 \times 10^{-2} \text{ tesla}$ which is normal to the plane of the loop. The loop is now moved normal to the direction of the field in the direction indicated, at a velocity of 0.4 m s^{-1} .

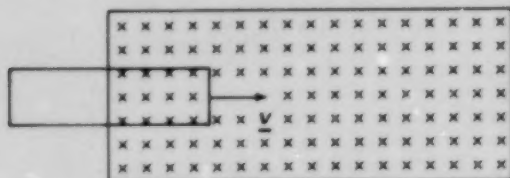
- 5 What is the magnitude of the EMF ($\mathcal{E}$) developed in the section YZ of the conductor?
 - A $2.4 \times 10^{-4} \text{ V}$
 - B $1.5 \times 10^{-3} \text{ V}$
 - C $2.4 \times 10^{-2} \text{ V}$
 - D $1.5 \times 10^{-1} \text{ V}$
- 6 In terms of $\mathcal{E}$, what is an expression for the $\vec{E}$ field induced in the conductor YZ?
 - A $0.02 \mathcal{E}$
 - B $0.5 \mathcal{E}$
 - C $2 \mathcal{E}$
 - D $50 \mathcal{E}$

Questions 7 & 8 refer to the following information:

The diagrams show four different situations in which a conducting loop is moving in a magnetic field. The magnetic field is shown directed into the page.

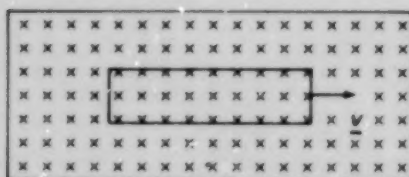
Case I

Conducting loop entering uniform magnetic field with constant velocity v .



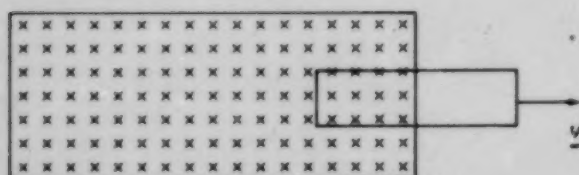
Case II

Conducting loop moving in a uniform magnetic field with decreasing velocity v .



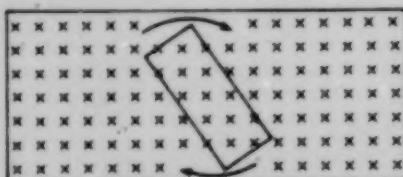
Case III

Conducting loop leaving uniform magnetic field with constant velocity v .



Case IV

Conducting loop rotating in uniform magnetic field in a clockwise direction in the plane of the page.



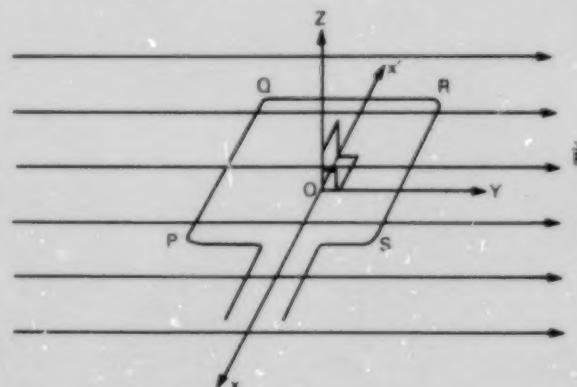
7 Which one of the following fully describes the situations in which no current is induced in the conducting loop?

- A Case II only
B Case IV only
C Cases I and III
D Cases II and IV
E none of the cases

8 Which one of the following gives the case or cases where the current induced in the conducting loop is in a clockwise direction?

- A Case I only
B Case III only
C Case IV only
D Cases III and IV
E Cases I, II and III

Questions 9-11 refer to the following information:



PQRS represents a rectangular conducting loop. The loop is horizontal in the plane of the axes OX and OY. The length of PQ is x m, and the length of QR is y m.

The loop rotates at a constant frequency of f s⁻¹ about the axis XOX' in a uniform magnetic field of B weber m⁻². The direction of B is OY.

9 In terms of f and other relevant symbols, which of the following is an expression for v , the speed of conductor PQ?

- A $2\pi xf$
B πxf
C $2\pi yf$
D πyf

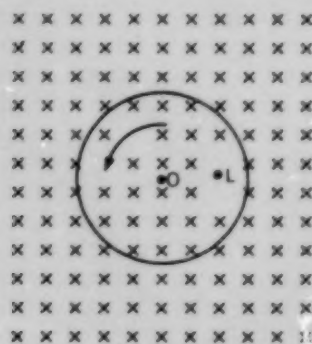
10 What is the value of the instantaneous induced EMF in the coil, when the coil has rotated through 90° from the indicated position?

- A 0
B Bxy
C $Bxyf$
D $\frac{Bxyf}{4}$

11 If, instead of rotating about XOX', the whole loop were moved (while still horizontal) in the direction OZ at speed s , what EMF would be induced in the loop?

- A 0
B Bxy
C $Bxys$
D $\frac{Bxy}{s}$

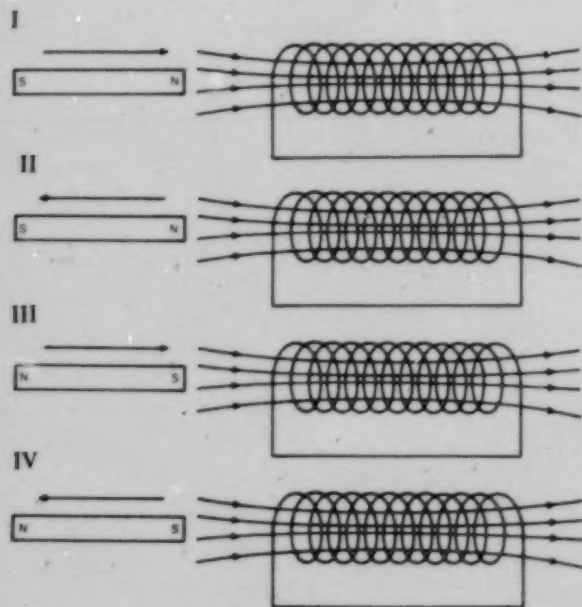
- 12 A uniform metal disc rotates about its centre O at a uniform rate in a uniform magnetic field directed into the page.



Which of the following is the direction of the magnetic force on an electron in the disc at point L?

- A out of the page C away from O
B into the page D toward O
- 13 In the key below, the direction of the motion of a magnet is shown inducing secondary flux lines in a solenoid in four different situations.

KEY



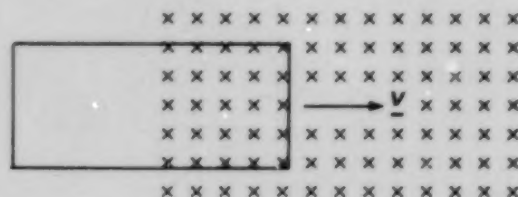
Which of the following would produce this situation?

- A Case I only C Cases II and III
B Case II only D Cases I and IV

- 14 The following two diagrams show a small rectangular conducting coil moving in different situations.

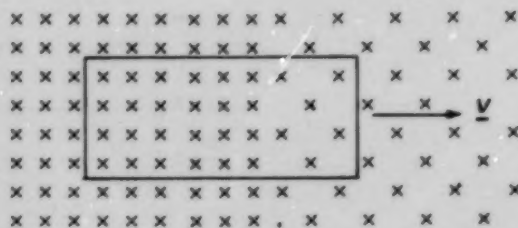
Case I

The coil moving into a uniform magnetic field with constant velocity v .



Case II

The coil moving into a region of weaker magnetic field with uniform velocity v .

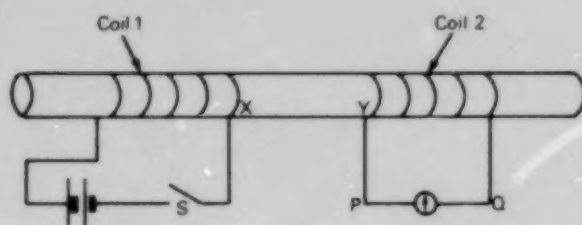


Which one of the following statements describes the direction of the currents flowing in the loop in Cases I and II?

- A clockwise in I and clockwise in II.
B anticlockwise in I and clockwise in II.
C anticlockwise in I and anticlockwise in II.
D clockwise in I and anticlockwise in II.
E none of the above, since the current is zero in Case II.

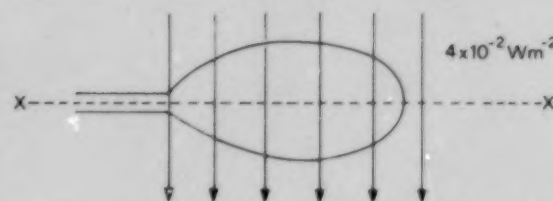
Questions 15-18 refer to the following information:

Two coils are wound on a soft-iron rod as shown. Coil 1 is connected to a battery and switch, S. Coil 2 is connected to a galvanometer.



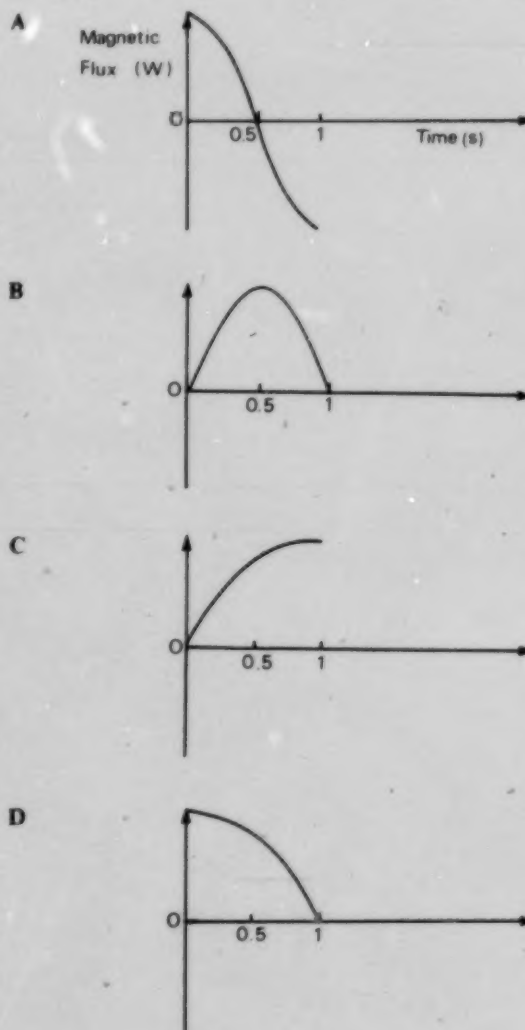
- 15 What is the direction of the magnetic field at X due to Coil 1 when S is closed?
- A to the right
B to the left
C to the right then to the left
D to the left then to the right
- 16 What is the direction of the induced magnetic field at Y due to Coil 2 immediately after S is closed?
- A to the right
B to the left
C to the right then to the left
D to the left then to the right
- 17 If the magnetic field through Coil 2 due to Coil 1 increases at a constant rate, then the galvanometer will indicate
- A a steadily increasing current flowing from P to Q.
B a steadily increasing current flowing from Q to P.
C a constant non-zero current flowing from P to Q.
D a constant non-zero current flowing from Q to P.
E zero current.
- 18 The right-hand coil is now slid to the right until it is half off the rod. It is supported so that its shape does not change. The switch S is again closed and, after a pause, opened. The maximum current shown by the galvanometer is
- A less than before.
B the same as before.
C more than before.

Questions 19 & 20 refer to the following information:

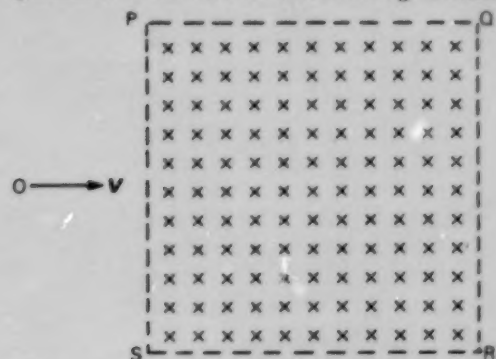


A coil of area 3 cm^2 is placed in a region of uniform magnetic field of magnitude $4 \times 10^{-2} \text{ W m}^{-2}$. The field is initially perpendicular to the plane of the coil. The coil is rotated through a quarter turn about the axis XX' in a time of one second.

- 19 What is the net change of flux through the coil during this rotation?
- A $6 \times 10^{-4} \text{ W}$ C $2.4 \times 10^{-5} \text{ W}$
B $3 \times 10^{-4} \text{ W}$ D $1.2 \times 10^{-5} \text{ W}$
- 20 If the coil were rotated from its initial position at a uniform rate, which of the following graphs would best represent the graph of the flux threading the coil against time during the rotation of a quarter turn?



Questions 21-24 refer to the following information:



The square region PQRS represents the limits of a uniform field of magnetic induction $\vec{B}$ directed into the page. The length of PQ is $L = 8 \text{ cm}$, and the magnitude, B , of $\vec{B}$ is $4.0 \times 10^{-2} \text{ tesla}$.

An α -particle travelling with speed $v = 4.0 \times 10^7 \text{ m s}^{-1}$ enters the region PQRS at a point mid-way between P and S.

Take the mass of an α -particle, m , as $6.7 \times 10^{-27} \text{ kg}$ and the charge of an α -particle, q , as $3.2 \times 10^{-19} \text{ coulomb}$.

- 21 Which one of the following is an expression for the magnitude of the force acting on the α -particle in the region of the field of magnetic induction?

A Bqv C $\frac{Bq}{mv}$
 B $\frac{Bv}{q}$ D $Bqmv$

- 22 Which one of the following is an expression for the radius of the path of the α -particle in the magnetic field?

A Bqv C $\frac{Bq}{mv}$
 B $Bqmv$ D $\frac{mv}{Bq}$

- 23 What is the value of the radius of the path of the α -particle in the magnetic field?

A $2.1 \times 10^{-1} \text{ m}$ C $4.8 \times 10^1 \text{ m}$
 B $2.1 \times 10^{-2} \text{ m}$ D $4.8 \times 10^2 \text{ m}$

- 24 In this particular case, it would be predicted that the α -particle would be deflected and

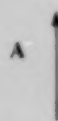
A pass out of the region of magnetic induction through QR.
 B pass out of the region of magnetic induction through RS.
 C pass out of the region of magnetic induction through PQ.
 D pass out of the region of magnetic induction through PS.
 E remain in the region of magnetic induction tracing out a circular path.

Questions 25 & 26 refer to the following information:

A uniform magnetic field approaches the surface of this page with a steady velocity directed into the page. The direction of the field is parallel to and directed up the page.

The following key indicates different directions.

KEY



A



D



B



E

out of the page



C



H

into the page

- 25 Which of the above indicates the direction of the electric field?

- 26 Which of the above indicates the direction of the motion of the electric field?

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 - 18 *The magnetic field*
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Test 20 Atomic physics

Directions

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- 2 Where required by the calculations, take

$$\sin 30^\circ = \frac{1}{2} = 0.50.$$

$$\sin 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\sin 60^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

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$$\tan 30^\circ = \frac{1}{\sqrt{3}} = 0.58.$$

$$\tan 45^\circ = 1$$

$$\tan 60^\circ = \sqrt{3} = 1.73$$

- 3 Unless otherwise instructed, neglect air resistance.

Jottings and calculations should be done on a separate sheet of paper.

Do not write on this test booklet
NOW TURN THE PAGE AND GO ON WITH THE TEST

- 1 Rutherford identified three types of radiation emitted from radium: alpha, beta and gamma. If these radiations are listed in order of increasing penetrating power in lead, with the least penetrating radiation listed first, the order is

A alpha, beta, gamma.
 B beta, gamma, alpha.
 C gamma, alpha, beta.
 D beta, alpha, gamma.

- 2 One modification to Rutherford's model of the atom that Bohr made was to state that

A electrons always remain in the same orbit.
 B when electrons move from an outer orbit to an inner orbit, they radiate energy.
 C electrons radiate energy as they move in curved paths.
 D when electrons move from an inner orbit to an outer orbit, they radiate energy.

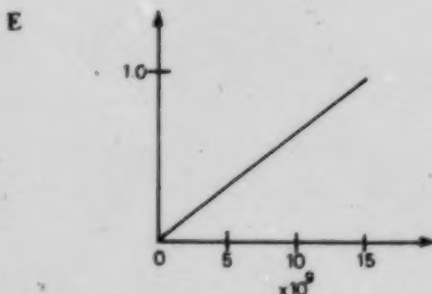
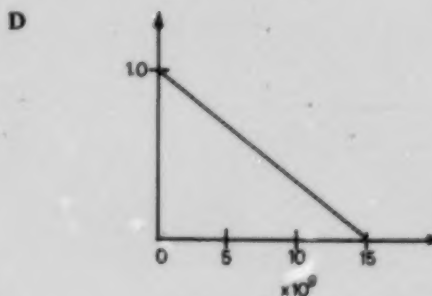
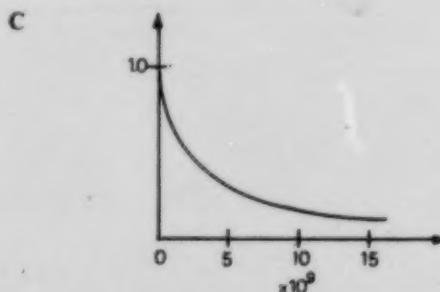
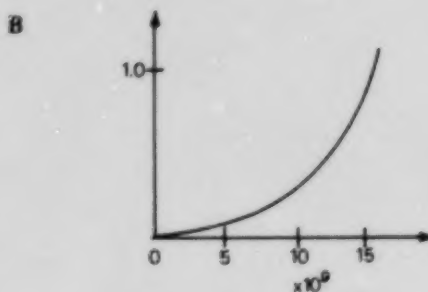
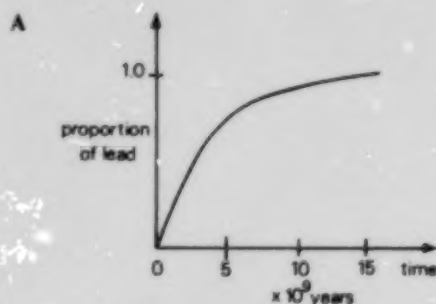
- 3 Different isotopes of an element have

A the same mass number and the same atomic number.
 B the same mass number and different atomic number.
 C different mass number and different atomic number.
 D different mass number and the same atomic number.

- 4 The radiation from a sample of Kr^{85} decreases to one-third of the original intensity I_0 in a period of 18 years. What would be the approximate intensity after 18 *more* years?

A $\frac{1}{2} I_0$ C $\frac{1}{6} I_0$
 B $\frac{1}{3} I_0$ D $\frac{1}{9} I_0$

- 5 Which graph best represents the change with time of the proportion of stable lead present in a sample that was originally pure uranium 238?



Questions 6-8 refer to the following information:

A radioactive substance is set up in front of a Geiger-Müller tube, which is connected to a counter. The reading on the counter is recorded by an observer at the end of every minute for 8 minutes. The results are shown:

Time (minutes)	Recording Reading
0	0
1	6015
2	8026
3	9016
4	9401
5	9541
6	9802
7	9636
8	9673

- 6 One recorded reading is obviously incorrect. At the end of which minute was it recorded?

A 2 C 6
B 4 D 7

- 7 Determine the count rate for each minute and use this to estimate the approximate half-life of the radioactive isotope in the substance. The half-life of the isotope is most probably

A less than $\frac{1}{2}$ minute.
B between $\frac{1}{2}$ minute and 1 minute.
C between 1 and $1\frac{1}{2}$ minutes.
D greater than $1\frac{1}{2}$ minutes.

- 8 The last reading shows a larger increase than would be expected. This could best be explained by assuming that

A the scalar counter was in error.
B the readings obtained were not exact.
C the time intervals in which counts were taken were too long.
D random fluctuations occur in the number of decays per minute.

Questions 9-12 refer to the following information:

The diagrams below represent tracks in a cloud chamber.

Chamber I has a magnetic field passing through it, perpendicularly into the page, while Chambers II and III do not have a magnetic field passing through it.



- 9 The particle that produced track S in Chamber I was most probably

A positively charged.
B negatively charged.
C neutral.

- 10 Suppose the particles that produced tracks S and T in Chamber I both carried a unit charge. The difference between their tracks can be best explained by one of the following. In comparison to particle S, particle T was most probably

A more massive and moved slower.
B more massive and moved faster.
C less massive and moved slower.
D less massive and moved faster.

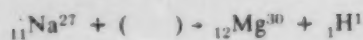
- 11 The tracks in Chamber II are made by a radioactive source. The particles which produced the tracks in Chamber II are most probably

A α -particles. C γ -rays.
B β -particles. D neutrons.

- 12 In Chamber III, a pair of tracks meet at point X, and two tracks form at point Y. It is probable that some particle travelling between X and Y connected the two events. The particle that leaves no tracks in Chamber III is most probably

A an α -particle. C a proton.
B a β -particle. D a γ -ray.

- 13 In the following equation



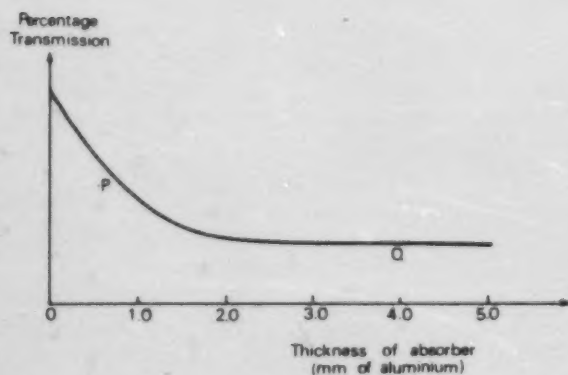
the particle omitted is

- A an alpha-particle. C a proton.
B a beta-particle. D a deuteron.

- 14 The mass number of a nucleus is equal to

- A the number of protons in the nucleus.
B the number of nucleons in the nucleus.
C the number of neutrons in the nucleus.
D the mass of the nucleus compared with the mass of a C^{12} nucleus.

- 15 The graph below shows the percentage transmission of radiation from a radioactive source passing through an increasing thickness of aluminium. The marked change of slope of the graph indicates the presence of a less penetrating radiation P and a more penetrating radiation Q being emitted by the radioactive source.

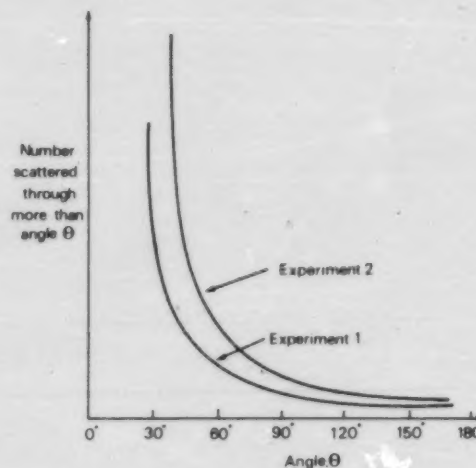


A magnetic field is then applied, and it is found that only part of the radiation is deflected. From this information, the two types of radiation present can be identified as

- A P - α C P - α
Q - β . Q - γ .
B P - β D P - γ
Q - γ . Q - β .

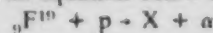
Questions 16 & 17 refer to the following information:

Geiger and Marsden probed the nature of the atom by observing the scattering of α -particles by metal foils. They plotted the number of α -particles scattered through more than angle θ as a function of θ . The graphs represent the results of two experiments.



- 16 Experiment 2 was performed with a foil of greater atomic number than was used in Experiment 1. The best reason which explains the difference in the results is that in Experiment 2
- A the forces between the nuclei and the α -particles are greater.
B the foil is denser.
C the distance of closest approach to the nuclei is smaller.
D there are more electrons in the new foil.
- 17 Which one of the following statements gives the best interpretation, consistent with Rutherford's model, of the experimental results of these scattering experiments of Geiger and Marsden?
- A The atom contains a dense, positively charged nucleus.
B The atom has electrons arranged in shells.
C The numerous electrons in the metal foil deflected the alpha-particles.
D The nucleus contains protons and neutrons.

- 18 The equation below represents a nuclear reaction.



The final nucleus X is

- A ${}_{10}\text{Ne}^{20}$. C ${}_8\text{O}^{16}$.
B ${}_8\text{O}^{18}$. D ${}_7\text{N}^{15}$.

- 19 An atom of mass number 11 captures an alpha-particle and then emits a proton.
The mass number of the resulting atom will be
- A 10. C 12.
B 11. D 14.
- 20 A deuterium atom consists of one proton, one neutron, and one electron. The sum of the masses of these three elementary particles is 2.016490 amu. The mass of a deuterium atom is measured as 2.014102 amu. An apparent loss in mass has occurred.
Which one of the following is the best explanation of this effect?
- A A nuclear reaction has occurred and released a subatomic particle.
B The effect is due to the release of energy when the deuterium is formed.
C The effect is due to the absorption of energy when the deuterium is formed.
D Light is emitted during the reaction.

Questions 21 & 22 refer to the following information:
The key below identifies several equations.

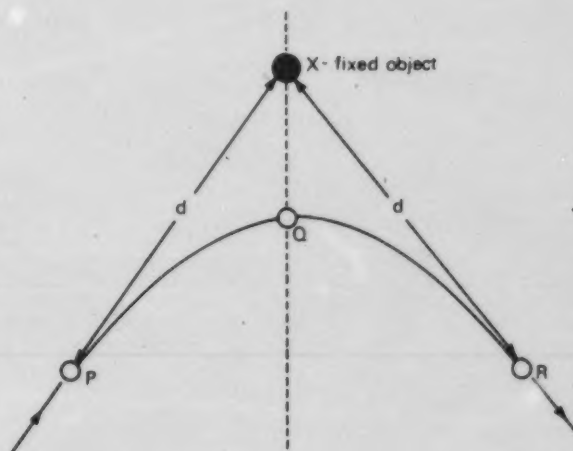
KEY

- A ${}_0^1\text{n}^1 + {}_{94}^{239}\text{Pu}^{239} \rightarrow {}_{94}^{240}\text{Pu}^{240} + {}_0^1\text{n}^1$
B $2{}_1^1\text{H}^1 + 2{}_1^1\text{H}^1 \rightarrow {}_2^4\text{He}^4 + 2{}_0^0\text{e}^0 + 2\nu + \gamma$
C ${}_0^1\text{n}^1 + {}_{92}^{238}\text{U}^{238} \rightarrow {}_{92}^{239}\text{U}^{239}$
D ${}_{92}^{239}\text{U}^{239} \rightarrow {}_{93}^{239}\text{Np}^{239} + {}_0^0\text{e}^0 + \nu$

Use the key to answer Questions 21 & 22.

- 21 Which equation represents the formation of a transuranic element?
- 22 Which equation is an example of nuclear fission?
- 23 Two nuclei which are isotopes of the same element can be represented as
- A ${}_{68}^{172}\text{L}^{172}$ and ${}_{70}^{170}\text{M}^{170}$. C ${}_{69}^{156}\text{E}^{156}$ and ${}_{69}^{170}\text{J}^{170}$.
B ${}_{69}^{156}\text{E}^{156}$ and ${}_{64}^{156}\text{G}^{156}$. D ${}_{70}^{170}\text{M}^{170}$ and ${}_{68}^{168}\text{Q}^{168}$.
- 24 The half life of thallium 209 is 132 seconds decaying to lead 209 with the emission of β -particles.
How long would it take for 75% of a particular sample of thallium to decay?
- A 99 s C 209 s
B 198 s D 264 s

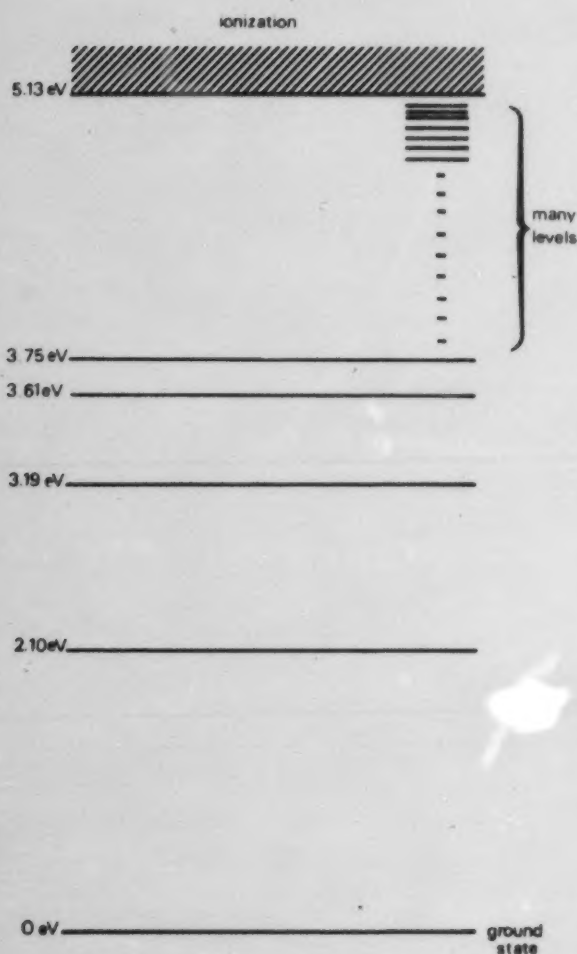
Questions 25 & 26 refer to the following information:
A sphere moves along a path near a fixed object X which repels it with a force equal to $\frac{c}{r^2}$ where c is a constant and r is the distance between centres of the sphere and the object.



The sphere was projected from infinity where its potential energy was zero. The interaction between the sphere and the object is an elastic one.

- 25 The kinetic energy of the sphere at Q is
- A zero.
B less than it was when at P, but not zero.
C greater than it was when at P.
D the same as it was when at P.
- 26 The kinetic energy of the sphere at R is
- A zero.
B less than it was when at P, but not zero.
C greater than it was when at P.
D the same as it was when at P.

Questions 27-29 refer to the following information:
The energy levels (of the valence electron) of atomic sodium are shown in the following diagram.



27 Atoms of sodium in the gaseous state are bombarded by electrons. What is the minimum bombarding energy, in eV, that will detach an electron from a sodium atom in its electronic ground state?

- A 2.10 eV C 5.13 eV
B 3.75 eV D 6.00 eV

28 The following key should be used when answering Question 28.

KEY

- I Some emitted photons would have an energy of 3.19 eV.
II Some emitted photons would have an energy of 0.42 eV.
III Some emitted photons would have an energy of 1.09 eV.
IV Some emitted photons would have an energy of 2.10 eV.

Which of the following would be observed when the energy of the bombarding electrons is 3.30 eV?

- A I only C I, III and IV only
B I and IV only D I, II, III and IV

29 The energy of a bombarding electron is 3.50 eV. If a photon of energy 1.09 eV is produced by a collision with a sodium atom, which is in its ground state, what is the energy, in eV, of the scattered electron?

- A 0.31 eV C 2.41 eV
B 1.09 eV D It cannot be determined as there is insufficient information.

Test 21 Quantum physics

Directions

This test is designed to help you discover any difficulties and misunderstandings you may have in the work that you recently studied in your physics course. It is not intended to allocate a grade or mark to you as a result of taking the test. After completing and marking the test you will be able to make your own record of the questions that you were unable to answer correctly. This record will indicate the parts of the course to which you need to give further attention immediately.

When answering the questions keep these points in mind:

- 1 Do not spend too much time on any one question. If it seems too difficult omit it and go on to the next question.
- 2 For each question, several alternatives are given. You should choose the **best** answer from these alternatives.

The following information may be useful and should always be accepted where relevant.

1 Take the acceleration due to gravity, g as 10 m s^{-2} .

2 Where required by the calculations, take

$$\sin 30^\circ = \frac{1}{2} = 0.50.$$

$$\sin 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\sin 60^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 30^\circ = \frac{\sqrt{3}}{2} = 0.87.$$

$$\cos 45^\circ = \frac{1}{\sqrt{2}} = 0.71.$$

$$\cos 60^\circ = \frac{1}{2} = 0.50.$$

$$\tan 30^\circ = \frac{1}{\sqrt{3}} = 0.58.$$

$$\tan 45^\circ = 1$$

$$\tan 60^\circ = \sqrt{3} = 1.73$$

3 Unless otherwise instructed, neglect air resistance.

Jottings and calculations should be done on a separate sheet of paper.

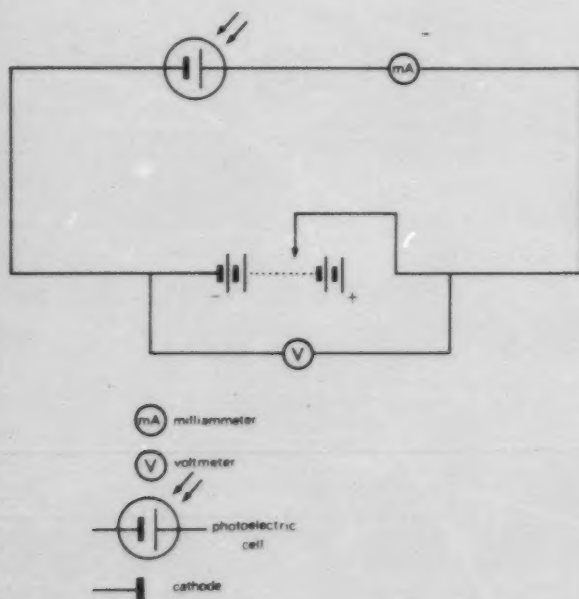
Do not write on this test booklet
NOW TURN THE PAGE AND GO ON WITH THE TEST

- The wave model of light describes light as a *continuous* electromagnetic wave. The wave model predicts that, when light falls on a metal, the excess energy obtained by the emitted photoelectrons is
 - increased as the intensity of light is increased.
 - increased as the frequency of light is increased.
 - unaffected by changes in the intensity of light.
 - decreased as the intensity of light is increased.
- The particle model of light describes light as a number of discrete energy quanta. The particle model predicts that, when light falls on a metal, the excess energy with which the photoelectrons are emitted is
 - increased as the intensity of light is increased.
 - increased as the frequency of light is increased.
 - unaffected by changes in the frequency of light.
 - decreased as the intensity of light is increased.
- Which one of the following has the greatest energy per photon?

A faint red light	C bright red light
B bright green light	D faint violet light

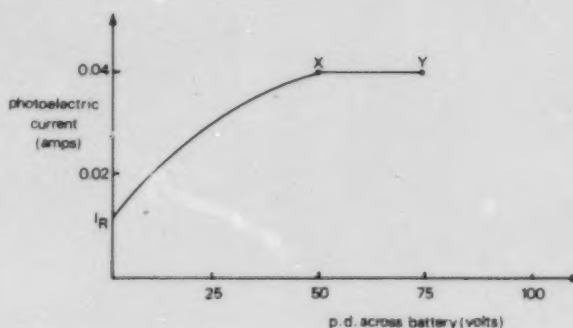
Questions 4–8 refer to the following information:

In the circuit diagram, the milliammeter is used to measure the photoelectric current (I), and the voltmeter to measure the potential difference across the photoelectric cell.



Light falls on the cathode and a photoelectric current results.

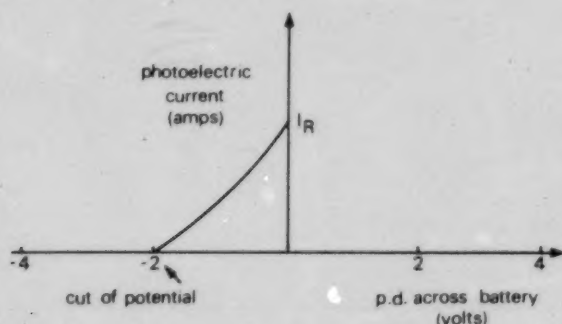
The graph shows the variation in current as the potential difference across the cell is changed.



- When the potential difference across the battery is zero, a photoelectric current I_R (the residual current) is observed. The best explanation for the existence of this residual current is that the
 - ammeter has a faulty zero reading.
 - voltmeter has a faulty zero reading.
 - light intensity is so high that it has produced sufficient photoelectrons.
 - frequency of the light is above the threshold frequency.
- The horizontal section of the graph, XY, suggests that
 - a battery with a higher potential difference is required to increase the photoelectric current.
 - the maximum number of photoelectrons emitted per second are arriving at the anode every second.
 - the photoelectrons leaving the cathode cell have the same kinetic energy.
 - the milliammeter has a maximum scale reading of 0.04 amps.

Questions 6-8 refer to the following additional information:

The battery is now connected in reverse and the potential difference across the battery is changed from zero to -5.0 volts. The corresponding photoelectric currents are measured and plotted on the graph.

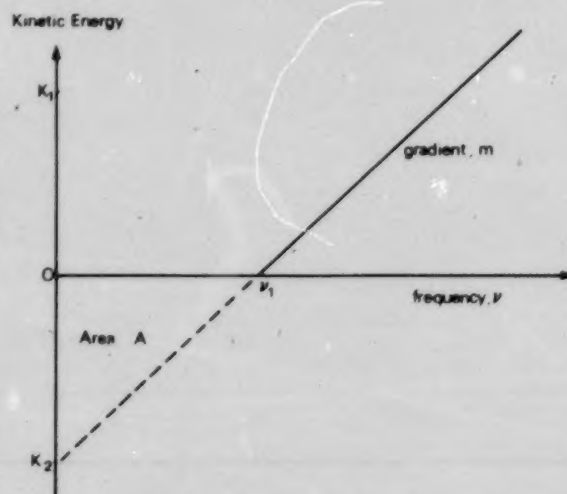


- 6 The photoelectric current decreases as the reverse potential increases, because
 - A less electrons are emitted per second from the cathode.
 - B the photoelectrons are emitted from the cathode with less kinetic energy than previously.
 - C fewer photoelectrons have kinetic energy sufficient to overcome the reverse potential.
 - D the anode has to be positive for a photoelectric current to exist.
- 7 If the intensity of the light is increased but the frequency is kept constant, then the cut-off potential will
 - A decrease.
 - B increase.
 - C remain constant.
- 8 If the intensity of the light is kept constant while the frequency is increased, then the magnitude of the cut-off potential will
 - A become less negative.
 - B become more negative.
 - C remain constant.
- 9 A certain metal has a work function of 3.7 eV. (Use $e = 1.6 \times 10^{-19}$ C and $h = 6.6 \times 10^{-34}$ Js)
The photoelectric threshold frequency of the metal will be

A 1.53×10^{14} Hz.	C 9.0×10^{14} Hz.
B 3.7 Hz.	D 5.9×10^{15} Hz.
- 10 The mass of an electron is approximately 1.0×10^{-30} kg. Taking Planck's constant as equal to 6.6×10^{-34} Js, the de Broglie wavelength for an electron travelling at a speed of 5.0×10^7 ms $^{-1}$ is

A 7.5×10^{-10} m.	C 2.6×10^{-11} m.
B 1.6×10^{-10} m.	D 1.3×10^{-11} m.

Questions 11 & 12 refer to the following information:
In the diagram, the frequency of incident light on a surface is plotted against the highest kinetic energy of the ejected electrons.

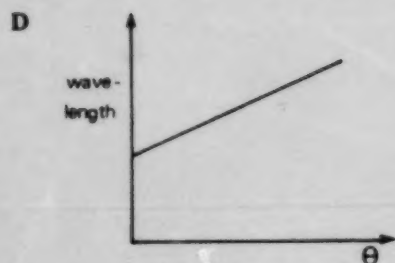
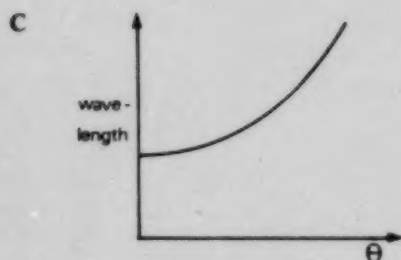
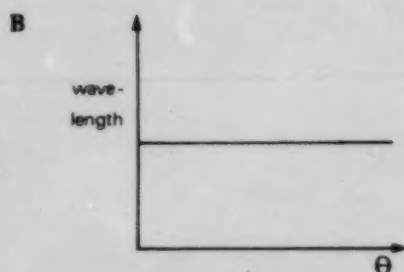
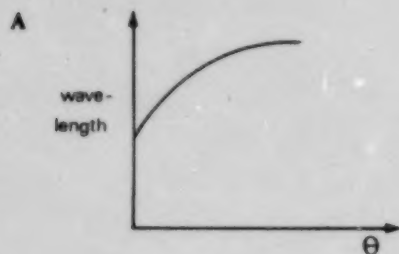


- 11 Which one of the following quantities gives a direct measure of the work function of the surface?

A ν_1	C K_2
B m	D A
- 12 The value K_1 gives a measure of the maximum kinetic energy of an ejected electron.
Which one of the following relates K_1 to E , the energy of the incident photon that released the electron?

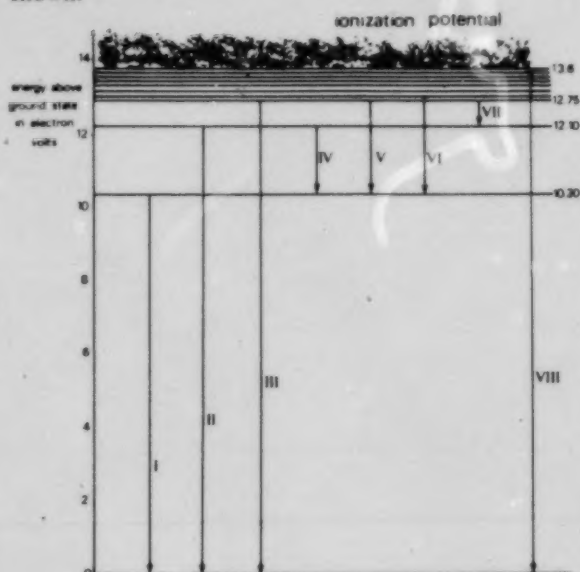
A $E = K_1$	C $E = K_1 - K_2$
B $E = K_1 + K_2$	D $E = K_1 + h\nu_1$
- 13 The scattering of an X-ray photon off an atom with the ejection of an electron is known as the Compton effect. The discovery of the Compton effect suggested that
 - A X-rays have a wave nature.
 - B X-rays could be considered to have a momentum.
 - C X-rays have a neutral charge.
 - D electrons have a wave nature.

14. In an experiment designed to study the Compton effect, the wavelengths of the scattered X-rays were measured at various angles θ to the direction of the incident beam. Which one of the graphs best illustrates the expected results?



Questions 15-17 refer to the following information:

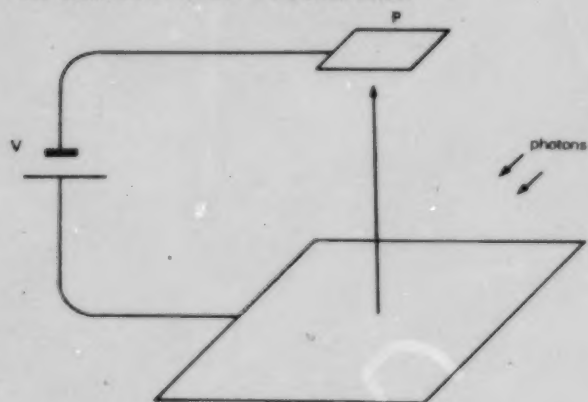
In the diagram, eight different transitions, I-VIII, between the energy levels of the hydrogen atom are shown.



15. Which transitions involve the ground state of the atom?
 A I, II, and III only C IV, V, and VI only
 B III, V, and VII only D I, II, III, and VIII only
16. In which one of the above transitions is a photon of the highest frequency emitted?
 A III C VII
 B IV D VIII
17. Which one of the above transitions would be accompanied by the emission of photons with a frequency of about 5×10^{14} cycle per second? ($h = 4.14 \times 10^{-15}$ electron volt second)
 A I C IV
 B III D VII
18. If an electron and a photon have the same momenta, then they have the same
 A kinetic energy only.
 B wavelength only.
 C wavelength and kinetic energy only.
 D wavelength, kinetic energy, and velocity.
19. The frequency of light incident on a given surface is ν , and the photoelectrons ejected have a maximum kinetic energy of E . If h = Planck's constant, the threshold frequency for the surface would be
 A $\nu - \frac{E}{h}$ C $\frac{E}{h}$
 B $\frac{E}{h} - \nu$ D ν

Question 20 refers to the following information:

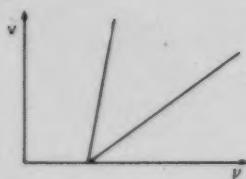
The apparatus illustrated in the diagram shows photons incident on a metal surface. The photoelectrons ejected from the surface are accelerated to a plate P by a potential difference V , and a current exists:



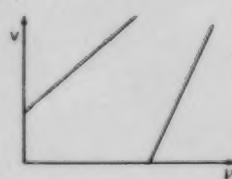
When the accelerating potential is made negative, a current still remains. However, for a large enough negative potential, the current ceases. The value of potential difference when the current first stops is called the 'stopping' potential.

Graphs I–IV represent 'stopping' potential, V , plotted against the frequency of the incident light, ν , for two slightly different photo-sensitive surfaces.

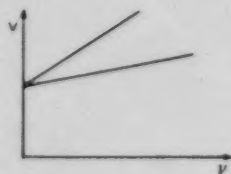
I



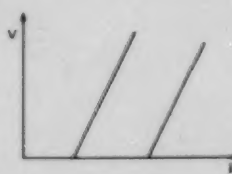
III



II



IV



20 Which one of the graphs shows the correct relation between V and ν ?

A I

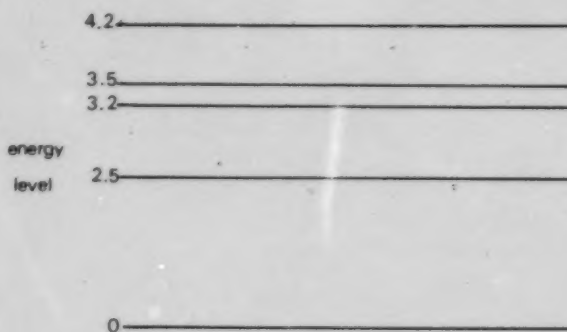
C III

B II

D IV

Question 21 refers to the following information:

The diagram represents the energy levels for an atom.



The energies (in eV) are relative to a ground state of zero. The electron is initially in its ground state and is struck by a photon of energy 3.0 eV.

21 Which one of the following best describes the result of the collision?

The atom

A and the photon share 3.0 eV of energy in proportion to their relative masses.

B absorbs the entire 3.0 eV of energy and the photon disappears.

C absorbs 2.5 eV and a photon moves with the remaining 0.5 eV of energy.

D absorbs no energy and the photon moves with the original 3.0 eV of energy.

22 X-rays emitted from an X-ray tube have intensities that

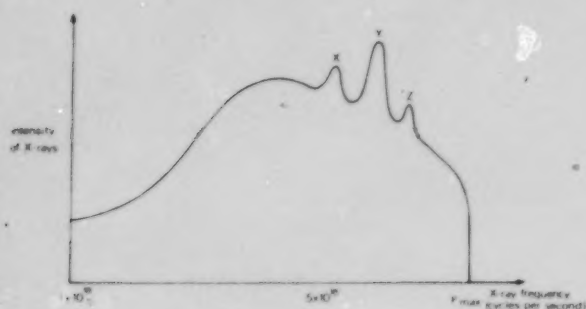
A depend on the energies of the electrons colliding with the anode only.

B depend on the filament current.

C depend on the frequency of the X-rays.

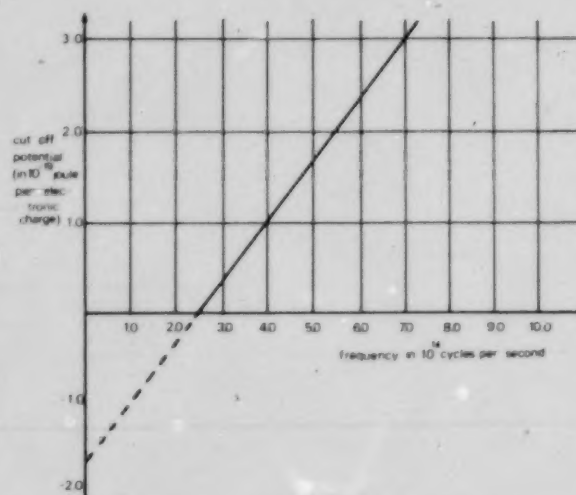
D are always constant.

Questions 23 & 24 refer to the following information:
The diagram represents the intensity of X-rays produced from a tube plotted against X-ray frequency, for a particular cathode filament current and a particular operating potential difference between cathode and anode.



- 23 In order to change the frequencies at which the peaks X, Y, and Z occur,
- A the filament current must be changed.
 - B the operating potential must be changed.
 - C another metal must be used for the anode.
 - D another metal must be used for the cathode.
- 24 In order to increase the intensity of peak Y,
- A the filament current only must be decreased.
 - B the operating potential only must be increased.
 - C both the filament current and the operating potential must be increased.
 - D either the filament current or the operating potential must be increased.

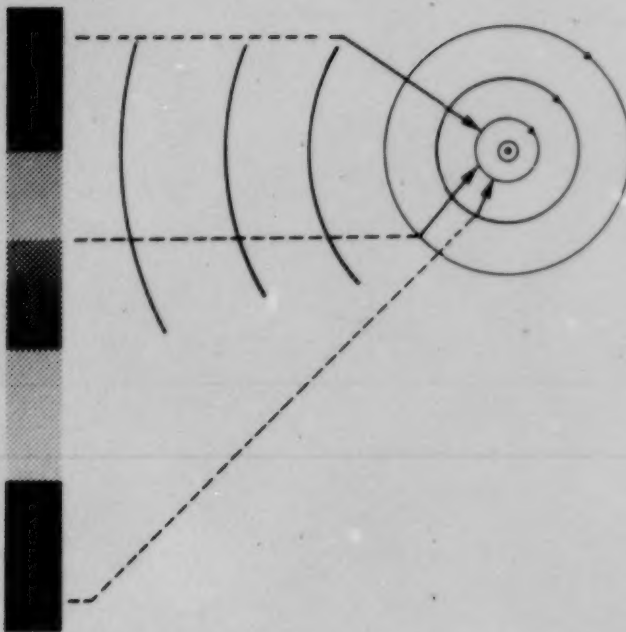
Questions 25 & 26 refer to the following information:
The graph represents the results obtained when various retarding potentials were used across the electrodes of a photoelectric cell whose cathode was made of caesium on silver.



- 25 Planck's constant can be obtained by
- A measuring the gradient of the curve.
 - B determining the area under the graph.
 - C reading the frequency axis intercept.
 - D reading the cut-off potential axis intercept.
- 26 What is the maximum kinetic energy of photoelectrons emitted from caesium on silver when a radiation of frequency 6×10^{14} cycles per second falls upon it?
- A 0.8×10^{-19} joule.
 - B 1.6×10^{-19} joule.
 - C 2.4×10^{-19} joule.
 - D 4.0×10^{-19} joule.



ACER Physics Unit Tests



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Diagnostic Aids

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The ACER Physics Unit Tests consist of the following publications.

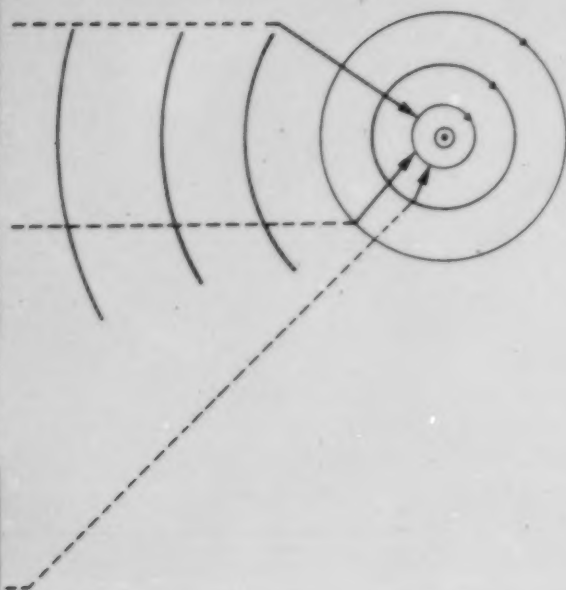
I A collection of tests covering the following topics

- 1 *Physical measurement*
- 2 *Vectors*
- 3 *Motion in one dimension*
- 4 *Motion on a plane*
- 5 *Dynamics*
- 6 *Work and energy*
- 7 *Linear momentum*
- 8 *Oscillations*
- 9 *Gravity and Kepler's laws*
- 10 *Waves*
- 11 *Light — reflection and refraction*
- 12 *Light — interference, diffraction and spectra*
- 13 *Models of light*
- 14 *Kinetic theory of gases*
- 15 *Static charges*
- 16 *Electric field and potential difference*
- 17 *Current electricity*
- 18 *The magnetic field*
- 19 *Induced EMF*
- 20 *Atomic physics*
- 21 *Quantum physics*

II A collection of 21 Diagnostic Aids covering topics corresponding to the tests.

III Teachers Handbook

ACER Physics Unit Tests symbol adapted from 'Spectrum of hydrogen gas', p. 338, *The Ascent of Man*, J. Bronowski, courtesy Rita Bronowski.



Diagnostic Aid 1 Physical measurement

Description

This diagnostic aid is one of a collection of 21 diagnostic aids corresponding to the 21 separate tests in the *Physics Unit Tests*.

In each diagnostic aid an explanation is provided so that the reasons why the responses are correct or incorrect are available to you.

To gain maximum benefit from the *Physics Unit Tests* weaknesses diagnosed need to be followed up. These diagnostic aids make it possible for you to proceed with this follow up in your own time. If you do not understand the discussion you are advised to seek help from your teacher.

References

The references throughout the Diagnostic Aids have been abbreviated. The abbreviations and full publication details are listed.

- Haber-Schaim: Haber-Schaim, U., Cross, J.B., Dodge, J.H., and Walter, J.A. *PSSC Physics*. 4th ed. Lexington, Mass.: D.C. Heath, 1976. (Reference is also made to 3rd ed.)
- Ingram: Ingram, A.D., Kuhl, D.H., McCarthy, I.E., Sandercock, E.R., Smith, W.F., and Waite, P.J. *Physics: A Laboratory-oriented Approach*. (Study Guide Leaving Part 1, Study Guide Matriculation Part 2). Adelaide: Rigby, 1971, 1972.
- Mayfield: Mayfield, J.M. Parham, R.T., and Webber, B.J. *Fundamentals of Senior Physics*. (Book 1, Book 2). Melbourne: Heinemann Educational Australia Pty Ltd, 1973.
- Project Physics: *Project Physics Course: Programmed Instruction Books* (Kinetic Molecular Theory of Gases, Waves 1-2, Equations 1-3, Vectors 1-3); *Text and Handbook* (Units 1-6). Sydney: Martin Educational, 1970.
- Williams: Williams, J.E., Trinkler, F.E., Metcalfe, H.C., and Lefler, R.W. *Modern Physics*. New York: Holt, Rinehart, & Winston, 1976.

The Australian Council for Educational Research Limited thanks the following publishers for donating textbooks used in referencing the aids: Heinemann Educational Australia Pty Ltd, Richmond, Victoria, for *Fundamentals of Senior Physics*. Rigby Limited, Box Hill, Victoria, for *Physics: A Laboratory-oriented Approach*.

Do not write on this booklet

1 - Correct Response: C

Discussion:

The SI system of units, based on the older metric system, uses a set of prefixes to indicate submultiples and multiples of the standard unit. These include:

Fractions	Value	Multiple	Value
pico	10^{-12}	kilo	10^3
nano	10^{-9}	mega	10^6
micro	10^{-6}	giga	10^9
milli	10^{-3}		
centi	10^{-2}		

References:

Ingram, Part 1, p. 268.

Mayfield, Book 1, p. 196.

2 and 3 Correct Response: 2 D 3 B

Discussion:

A simple rule to use when calculating, using measurements, is not to quote any more significant figures in the answer than are contained in the measurement which has the least accuracy.

e.g.: $52.39 + 4.215$ can be written as

$$52.39?$$

$$4.215$$

$56.60?$, thus no more than two decimal places should be quoted.

Another example: $3.19 \times 2.435 = 7.77$

i.e.: 3 significant figures $\times$ 4 significant figures
 $\rightarrow$ 3 significant figures.

References:

Ingram, Part 1, p. 209.

Williams, pp. 32, 33.

4 Correct Response: C

Discussion:

The answers quoted are examples of 'Orders of Magnitude'. An order of magnitude is the nearest power of 10 to the answer, using $\sqrt{10} = 3.16$ as the cut off level.

e.g.: 2×10^8 is of order of magnitude 10^8

8.95×10^{-3} is of order of magnitude 10^{-2}

In this problem

$$V = \frac{4}{3}\pi r^3$$

$$\Rightarrow 4 \times 10^9 = \frac{4}{3}\pi r^3$$

$$\Rightarrow 12 \times 10^9 = 4\pi r^3$$

$$\Rightarrow 3 \times 10^9 = \pi r^3$$

$$\Rightarrow 10^9 \approx r^3 \text{ if we take } \pi \approx 3$$

$$\Rightarrow r \approx \sqrt[3]{10^9} = 10^3$$

so 10^3 is the nearest power of 10.

References:

Project Physics, Unit 1, p. 6.

Williams, p. 36.

5 Correct Response: C

Discussion:

To calculate the total error with a formula it is necessary to first work out each absolute error as a percentage error, and then *add* the errors involved with measurements which are multiplied or divided:

$$r = \frac{V^2}{2S} = \frac{V \times V}{2S}$$

Here, 2.01 ± 0.02 has an error of about 1%

10.340 ± 0.005 has an error of about 0.05%,

so the total error is about $1\% + 1\% + 0.05\%$

$$= 2.05\% \approx 2\%$$

$$r = \frac{(2.01)^2}{2 \times 10.340} = 0.1954 \pm 2\%$$

$$= 0.1954 \pm 0.004$$

$$= 0.195 \pm 0.004, \text{ since}$$

the fourth decimal place has no significance here.

References:

Ingram, Part 1, p. 208.

Mayfield, Book 1, p. 19.

Williams, p. 30.

6 Correct Response: A

Discussion:

In the system of electrical units, the base or fundamental unit is the ampere. All other units are based on this. In particular, the coulomb, the unit of charge, is defined as an ampere second.

The ampere is chosen as the base measurement because it is easier to measure current more accurately than other quantities.

References:

Haber-Schaim, 3rd & 4th ed., p. 516, para 3.

Ingram, Part 1, pp. 165-166.

Mayfield, Book 1, p. 89.

Project Physics, Unit 4, p. 39.

Williams, p. 472.

7 Correct Response: A**Discussion:**

The watt is a unit of power in the SI system. Power is the time rate of doing work,

$$\begin{aligned} \text{i.e.: } P &= \frac{\text{Work}}{\text{Time}} \\ &= \frac{\text{Force} \times \text{Distance}}{\text{Time}} \\ &= \frac{\text{Mass} \times \text{Acceleration} \times \text{Distance}}{\text{Time}} \end{aligned}$$

$$\begin{aligned} \text{so the unit is } &\frac{\text{kg} \times \text{ms}^{-2} \times \text{m}}{\text{s}} \\ &= \text{kg m}^2 \text{ s}^{-3} \end{aligned}$$

References:

Haber-Schaim, 3rd & 4th ed., p. 357 and footnote.
Ingram, Part 1, p. 86.
Mayfield, Book 1, p. 67.
Project Physics, Unit 3, p. 48.
Williams, p. 135.

8 and 9 Correct Responses: 8 D**9 B****Discussion:**

The unit of electrical potential is defined as the volt.
The unit of charge is the coulomb.

References:

Haber-Schaim, 3rd ed., p. 460, para 4 and p. 461.
Haber-Schaim, 4th ed., p. 437; para 3 and p. 438.
Ingram, Part 1, pp. 132, 166.
Mayfield, Book 1, pp. 89, 118.
Project Physics, Unit 4, pp. 39, 55.
Williams, p. 386 and p. 473.

10 Correct Response: A**Discussion:**

In the SI system current is the fundamental or base quantity and charge is defined as current $\times$ time.
Hence the coulomb is an ampere $\times$ second. (See also Item 6.)

References:

Haber-Schaim, 3rd ed., p. 461, para 3 and 4th ed., p. 460, para 3.
Ingram, Part 1, p. 166.
Mayfield, Book 1, p. 89.
Project Physics, Unit 4, p. 39.

11 Correct Response: B**Discussion:**

Since micro = 10^{-6} (see Item 1) then 1 micro-coulomb = 10^{-6} coulomb.

References:

Ingram, Part 1, p. 268.
Mayfield, Book 1, p. 196.
Williams, p. 697.

12 Correct Response: A**Discussion:**

Force is defined from Newton's second Law as mass $\times$ acceleration

$$\begin{aligned} &= \text{mass} \times \frac{\text{velocity}}{\text{time}} \\ &= \text{mass} \times \frac{\text{distance}}{\text{time}^2} \\ &= \text{MLT}^{-2} \end{aligned}$$

References:

Ingram, Part 1, p. 220.
Mayfield, Book 1, p. 18.
Project Physics, Unit 1, pp. 82, 83.

13 Correct Response: C**Discussion:**

$$\begin{aligned} \text{If } P &= RQ^x\sqrt{S} \\ &= RQ^xS^{\frac{1}{2}} \end{aligned}$$

and the quantities have the dimensions listed, then:

LHS has dimensions of T

RHS has dimensions $(LT^{-2})^xL^{\frac{1}{2}}$

$$\text{Now, } (LT^{-2})^xL^{\frac{1}{2}} = L^{(x+\frac{1}{2})}T^{-2x}$$

so, from L , $x + \frac{1}{2} = 0$ and, from T , $-2x = 1$

hence, $x = -\frac{1}{2}$.

References:

Ingram, Part 1, pp. 220, 221.
Mayfield, Book 1, p. 18.

14 Correct Response: A**Discussion:**

$$\text{Since } E = mc^2$$

then the unit of energy should be that of mass $\times$ (speed)²

$$\begin{aligned} &= \text{kg}(\text{m s}^{-1})^2 \\ &= \text{kg m}^2 \text{ s}^{-2} \end{aligned}$$

References:

Ingram, Part 1, p. 220.
Mayfield, Book 1, p. 18.

15 Correct Response: D**Discussion:**

$$\text{Since } E = mc^2$$

then E is approximately $10^{-27} \times (3 \times 10^8)^2$,

$$\text{i.e.: } E \approx 9 \times 10^{-11}$$

$$\approx 10 \times 10^{-11}$$

$$\approx 10^{-10}$$

So the order of magnitude of E is 10^{-10} .

References:

Williams, p. 36.

16 Correct Response: B**Discussion:**

If $E = mc^2 + T$, then T must have the same units as E or mc^2 ,

i.e.: T has units $\text{kg m}^2 \text{s}^{-2}$

(See Item 14 also.)

References:

Ingram, Part 1, p. 220.

Mayfield, Book 1, p. 18.

17 Correct Response: D**Discussion:**

If $T = \frac{1}{2}\rho gh^4$

then the dimensions of T are ML^2T^{-2} . (See Item 16.)

On the other side of the equation, the dimensions are

$$[\rho]L T^{-2} L^4 \\ = [\rho]L^5 T^{-2}$$

Hence $ML^2T^{-2} = [\rho]L^5T^{-2}$

$$\therefore [\rho] = \frac{ML^2T^{-2}}{L^5T^{-2}} = ML^{-3}$$

In the SI system, the unit of ρ would then be kg m^{-3} .

References:

Ingram, Part 1, p. 220.

Mayfield, Book 1, p. 18.

18 Correct Response: D**Discussion:**

Using this vernier, the length of the object on the main scale is 1.2^+ . The second decimal place is found by searching for the mark on the vernier scale which lines up with a mark on the main scale. In this case, it is the second mark on the vernier scale, so the length of the body is 1.22 .

19 Correct Response: D**Discussion:**

A newton is the unit of force, and is the force needed to produce an acceleration of 1 m s^{-2} on a mass of 1 kg . (Remember that $F = ma$.)

so $1\text{N} = 1 \text{ kg m s}^{-2}$.

References:

Haber-Schaim, 3rd and 4th ed., p. 235.

Ingram, Part 1, p. 70.

Mayfield, Book 1, p. 42.

Project Physics, Unit 1, pp. 82, 83.

Williams, p. 48.

20 and 21 Correct Responses: 20 B

21 A

Discussion:

A joule is the amount of work done by a force of 1 newton working through a distance of 1 metre .

So $1 \text{ joule} = 1 \text{ newton} \times 1 \text{ metre} = \text{newton metre}$.

$$= 1 \text{ kg m s}^{-2} \times 1 \text{ m}$$

$$\Rightarrow \text{joule} = \text{kg m}^2 \text{s}^{-2}.$$

References:

Haber-Schaim, 3rd ed., and 4th ed., p. 327.

Mayfield, Book 1, p. 65.

Project Physics, Unit 3, p. 33.

Williams, p. 131.

22 Correct Response: C**Discussion:**

The expansion was $6.569 - 6.549$ and hence the difference is 0.020 . It is reasonable to expect three decimal places in the answer since the two original measurements were made to an accuracy of three decimal places.

References:

Ingram, Part 1, p. 209.

23 Correct Response: D**Discussion:**

The prefix mega stands for 10^{+6} (See Item 1.) Hence a megawatt is 10^6 watt .

References:

Ingram, Part 1, p. 268.

Mayfield, Book 1, p. 196.

Williams, p. 697.

24 Correct Response: B**Discussion:**

The unit for magnetic flux density is the *tesla* in the SI system. The weber is the unit of magnetic flux.

References:

Ingram, Part 1, p. 171.

Mayfield, Book 1, p. 108.

Project Physics, Unit 4, p. 63.

25 Correct Response: A**Discussion:**

The pascal is the SI unit of pressure.

$$\text{Since pressure} = \frac{\text{force}}{\text{area}}$$

$$\text{its unit is } \frac{\text{newton}}{\text{metre}^2}$$

$$= \text{newton metre}^{-2}.$$

26 Correct Response: B

Discussion:

The weber is the SI unit of magnetic flux, ϕ .

One formula which uses ϕ is

$$\mathcal{E} = \frac{-d\phi}{dt}$$

and so the unit of ϕ could be volt second.

This unit can be replaced by fundamental units in the following manner:

$$\begin{aligned}\text{volt second} &= \frac{\text{joule}}{\text{coulomb}} \times \text{second} \\ &= \frac{\text{kg m}^2 \text{s}^{-2}}{\text{coulomb}} \times \text{s} \\ &= \frac{\text{kg m}^2 \text{s}^{-1}}{\text{coulomb}},\end{aligned}$$

but a coulomb = ampere second.

$$\begin{aligned}\text{So units of 1 weber} &= \frac{\text{kg m}^2 \text{s}^{-1}}{\text{A s}} \\ &= \text{kg m}^2 \text{s}^{-2} \text{A}^{-1}.\end{aligned}$$

27 Correct Response: B

Discussion:

An average car is about 1 tonne in mass,

i.e.: about 10^3 kg.

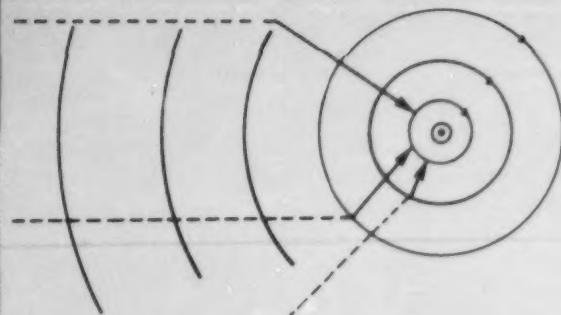
28 Correct Response: C

Discussion:

$$\begin{aligned}60 \text{ km h}^{-1} &= 60 \times 10^3 \text{ m h}^{-1} \\ &= \frac{60 \times 10^3}{3600} \text{ m s}^{-1} \\ &= \frac{6 \times 10^4}{3.6 \times 10^3} \text{ m s}^{-1} \\ &= \frac{60}{3.6} \text{ m s}^{-1}\end{aligned}$$

and this is approximately 17.

The answer nearest to this is 10.



Diagnostic Aid 2 Vectors

Description

This diagnostic aid is one of a collection of 21 diagnostic aids corresponding to the 21 separate tests in the *Physics Unit Tests*.

In each diagnostic aid an explanation is provided so that the reasons why the responses are correct or incorrect are available to you.

To gain maximum benefit from the *Physics Unit Tests* weaknesses diagnosed need to be followed up. These diagnostic aids make it possible for you to proceed with this follow up in your own time. If you do not understand the discussion you are advised to seek help from your teacher.

References

The references throughout the Diagnostic Aids have been abbreviated. The abbreviations and full publication details are listed.

- Haber-Schaim:** Haber-Schaim, U., Cross, J.B., Dodge, J.H., and Walter, J.A. *PSSC Physics*. 4th ed. Lexington, Mass.: D.C. Heath, 1976. (Reference is also made to 3rd ed.)
- Ingram:** Ingram, A.D., Kuhl, D.H., McCarthy, I.E., Sandercock, E.R., Smith, W.F., and Waite, P.J. *Physics: A Laboratory-oriented Approach*. (Study Guide Leaving Part 1, Study Guide Matriculation Part 2). Adelaide: Rigby, 1971, 1972.
- Mayfield:** Mayfield, J.M. Parham, R.T., and Webber, B.J. *Fundamentals of Senior Physics*. (Book 1, Book 2). Melbourne: Heinemann Educational Australia Pty Ltd, 1973.
- Project Physics:** *Project Physics Course: Programmed Instruction Books* (Kinetic Molecular Theory of Gases, Waves 1-2, Equations 1-3, Vectors 1-3); *Text and Handbook* (Units 1-6). Sydney: Martin Educational, 1970.
- Williams:** Williams, J.E., Trinkle, F.E., Metcalfe, H.C., and Lefler, R.W. *Modern Physics*. New York: Holt, Rinehart, & Winston, 1976.

The Australian Council for Educational Research Limited thanks the following publishers for donating textbooks used in referencing the aids: Heinemann Educational Australia Pty Ltd, Richmond, Victoria, for *Fundamentals of Senior Physics*. Rigby Limited, Box Hill, Victoria, for *Physics: A Laboratory-oriented Approach*.

Do not write on this booklet

1 Correct Response: B

Discussion:

Scalar quantities are physical quantities which consist of a magnitude (size), a unit, but no direction. They contrast with vector quantities, that is, those quantities like displacements which are added and subtracted by vector mathematics, which have a direction as well as a magnitude and a unit.

In choosing the correct response, it is probably easy to see that there is no direction in the quantity time. 'Distance' is defined to mean no more than the length measurement between two points, and is thus also a scalar quantity. (The term 'displacement' describes the vector quantity comprising distance and direction too.)

Energy is defined as a scalar quantity and therefore power, which is just the rate of transferring energy, must be a scalar too.

(A is incorrect as force and velocity are both vector quantities. In C, momentum, as well as force and velocity, are vector quantities. D is incorrect, as displacement is a vector quantity, and weight, being a particular kind of force, is a vector too.)

References:

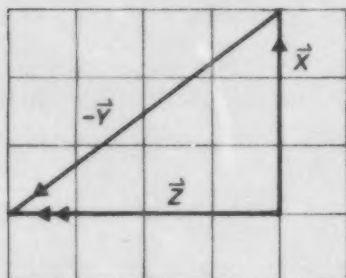
Haber-Schaim, 4th ed., p. 201.
Ingram, Part 1, p. 224.
Mayfield, Book 1, pp. 8, 21.
Project Physics, Unit 1, pp. 73-75.
Williams, p. 49.

2 and 3 Correct Responses: 2 B 3 A

Discussion:

One method to subtract vector $\vec{Y}$ from vector $\vec{X}$, is to ADD the vector $-\vec{Y}$ to vector $\vec{X}$, by drawing on to the end of $\vec{X}$ a vector equal in size but opposite in direction to vector $\vec{Y}$.

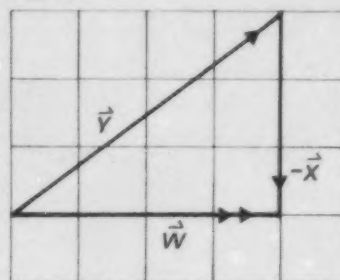
The result, shown as $\vec{Z}$ on the diagram, is four units long.



Item 3 refers to a different vector, namely $\vec{Y} - \vec{X}$.

One could use the fact that vector $\vec{Y} - \vec{X}$ must be a vector equal in size but opposite in direction to vector $\vec{X} - \vec{Y}$.

Alternatively, one could subtract vector $\vec{X}$ from vector $\vec{Y}$ as in the diagram, where the result is shown as $\vec{W}$.



Either way, the result is a vector in a horizontal direction; the angle it makes with the horizontal is thus zero.

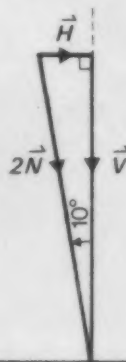
References:

Haber-Schaim, 4th ed., p. 201.
Ingram, Part 1, p. 226.
Mayfield, Book 1, pp. 21, 22.
Project Physics, Programmed Instruction Booklet 'Vectors'.

4 and 5 Correct Responses: 4 A 5 C

Discussion:

One obtains the horizontal component ($\vec{H}$) and the vertical component ($\vec{V}$) of the 2 newton force by constructing a right angled triangle as shown.



For item 4: $\frac{V}{2} = \cos 10^\circ$
 $V = 2 \cos 10^\circ$

For item 5: $\frac{H}{2} = \sin 10^\circ$
 $H = 2 \sin 10^\circ$

References:

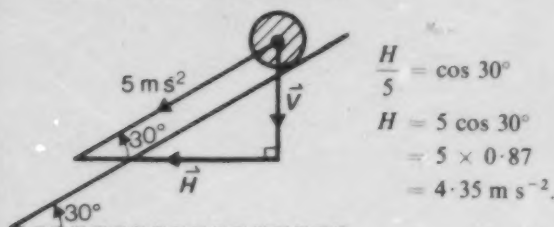
Haber-Schaim, 4th ed., p. 202.
Ingram, Part 1, p. 226.
Mayfield, Book 1, p. 28.
Project Physics, Programmed Instruction Booklets 'Vectors'.
Williams, p. 49.

6 and 7 Correct Responses: 6 B

7 A

Discussion:

The finding of components of the vector acceleration is similar to the finding of components of the vector force in items 4 and 5. Thus, for item 6: Horizontal component $\vec{H}$ is found from



$$\begin{aligned}\frac{H}{5} &= \cos 30^\circ \\ H &= 5 \cos 30^\circ \\ &= 5 \times 0.87 \\ &= 4.35 \text{ m s}^{-2}\end{aligned}$$

Similarly, for item 7: Vertical component $\vec{V}$ is found from

$$\begin{aligned}\frac{V}{5} &= \sin 30^\circ \\ V &= 5 \sin 30^\circ \\ &= 5 \times 0.50 \\ &= 2.5 \text{ m s}^{-2}\end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 202.
Ingram, Part 1, p. 226.
Mayfield, Book 1, p. 28.
Project Physics, Programmed Instruction Booklets 'Vectors'.
Williams, p. 51.

8 Correct Response: D

Discussion:

A body moving at a constant speed in a circle is continually changing direction, and hence is accelerated. Therefore there must be a net force acting on the body. Newton's Law $\vec{F} = m\vec{a}$ shows that the net force has the same direction as the acceleration.

Since the centripetal acceleration continually changes direction so as to always act in the direction from the body towards the centre of the circular path, then the net force has a direction which keeps changing in this way too. Again, the magnitude of the acceleration is constant and equal to

$$\frac{4\pi^2 r}{T^2} \text{ or } \frac{v^2}{r}$$

and thus the net force must have constant magnitude, equal to m times the acceleration value.

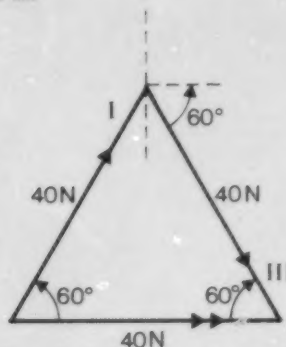
References:

Haber-Schaim, 4th ed., p. 211.
Ingram, Part 1, pp. 26-28.
Mayfield, Book 1, pp. 30, 46.
Project Physics, Unit 1, pp. 109-113.
Williams, p. 110.

9 Correct Response: B

Discussion:

One way of finding the resultant of all three forces is to add I and III (see diagram) then add their sum to force II.



The sum of I and III is a 40 N force in the same direction as II, so the sum of all three is 50 N in the direction of II.

References:

Haber-Schaim, 4th ed., p. 235.
Ingram, Part 1, pp. 225, 226.
Mayfield, Book 1, p. 21.
Project Physics, Unit 1, pp. 73-75.
Williams, pp. 55-57.

10, 11 and 12 Correct Responses: 10 B

11 C

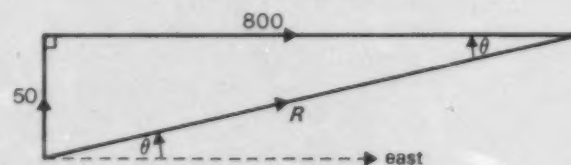
12 C

Discussion:

10 The resultant velocity of the plane relative to the earth is the vector sum of the plane's velocity relative to the air and the wind velocity. Diagram B gives the correct vector addition of these two velocities.

11 In diagram B, if $\vec{R}$ represents the resultant, then the application of Pythagoras' Theorem to the right angled triangle shows that

$$\begin{aligned}R^2 &= 50^2 + 800^2 \\ &= 2500 + 640\,000 \\ &= 642\,500 \\ R &= 802 \text{ km h}^{-1}\end{aligned}$$



12 From diagram B, the direction of the resultant velocity is slightly north of due east. It is possible to proceed further and calculate at what angle, to due east, the resultant lies, using

$$\tan \theta = \frac{50}{800}$$

References:

Haber-Schaim, 4th ed., p. 212.
 Ingram, Part 1, pp. 30, 31.
 Williams, pp. 75-77.

13 and 14 Correct Responses: 13 C
 14 A

Discussion:

- 13 The instantaneous velocity of a body travelling in a curved path is given by a vector whose direction is a tangent to the curve at the point on the path occupied by the body. Thus C gives the correct velocity vector.
- 14 The displacement of the ball is its change of position, and would be represented by a vector drawn as a straight line from point 1 to point 2. Its magnitude is thus the straight line distance from point 1 to point 2.

References:

Haber-Schaim, 4th ed., pp. 204-206.
 Ingram, Part 1, p. 8.
 Mayfield, Book 1, p. 23.
 Project Physics, Unit 1, pp. 23-25.
 Williams, p. 73.

15 Correct Response: D

Discussion:

The change in velocity is found by subtracting the initial velocity from the final velocity.

Hence, change in velocity = $\vec{Y} - \vec{X}$.

This is done by adding a vector opposite to $\vec{X}$, that is 20 units upwards, to the vector $\vec{Y}$. This gives a vector 35 units upwards.

References:

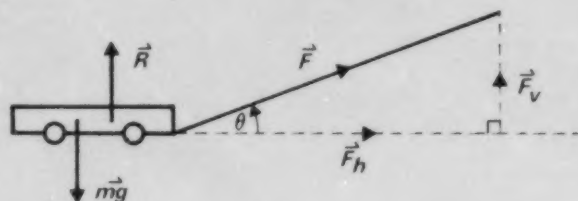
Haber-Schaim, 4th ed., p. 205.
 Ingram, Part 1, pp. 25, 26.
 Mayfield, Book 1, p. 25.

16 and 17 Correct Responses: 16 C
 17 C

Discussion:

Finding the components of the vector $\vec{F}$ involves completing the right angled triangle with $\vec{F}$ as hypotenuse. Then,

for item 16: $\vec{F}_h$ is the component of the force in the direction of motion of the trolley.



From the diagram, $\frac{F_h}{F} = \cos \theta$

$$F_h = F \cos \theta.$$

For item 17: The vertical forces acting on the trolley are,

Weight force = mg newton downwards.

Component $\vec{F}_v$ of the applied force = $F \sin \theta$ newton upwards. There is an upward force R newton exerted by the ground on the trolley to support it.

Since there is no vertical acceleration, of the trolley, either up or down, then the sum of the three vertical forces must be zero.

If we call upwards positive, it follows that,

$$R + F \sin \theta - mg = 0$$

$$R = mg - F \sin \theta \text{ newton.}$$

References:

Haber-Schaim, 4th ed., pp. 202, 235.
 Ingram, Part 1, p. 226.
 Williams, pp. 49, 50; pp. 57, 58.

- 18-21 Correct Responses: 18 D
19 C
20 B
21 C

Discussion:

- 18 One way of adding vectors $\vec{X}$, $\vec{Y}$ and $\vec{Z}$ is to find the sum of any two of them (say, by the triangle method), and then add their sum to the third one by the same method.

For example, $\vec{X}$ and $\vec{Y}$ could be added to form their sum $\vec{R}$.

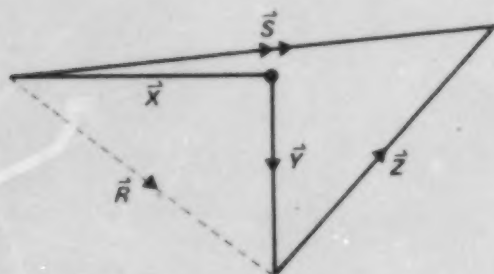


Now add $\vec{R}$ to $\vec{Z}$:



$\vec{S}$ is thus the sum of all three vectors.

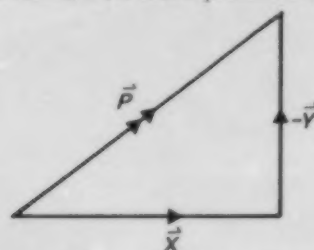
All this could be done on the one figure, as follows:



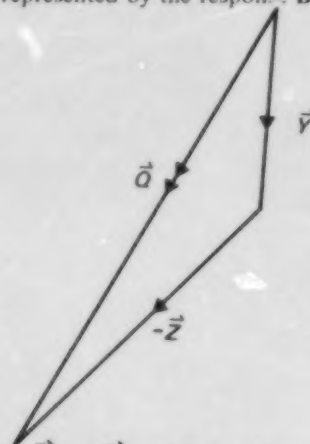
This is figure D, since $\vec{R}$ could be omitted as merely an intermediate sum.

- 19 $\vec{X} - \vec{Y}$ is obtained by adding $-\vec{Y}$ (a vector opposite to $\vec{Y}$) to $\vec{X}$.

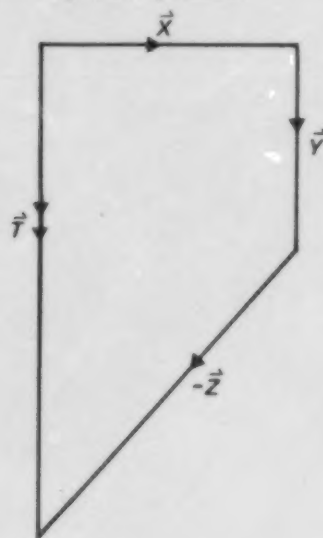
The result, $\vec{P}$, is best represented by the response C.



- 20 Using a similar method to item 19, the result $\vec{Q}$ is best represented by the response B.



- 21 Adding $\vec{X}$ and $\vec{Y}$, and then adding a vector opposite to $\vec{Z}$ to the result, gives $\vec{T}$ as the sum. This is best represented by the response C.



References:

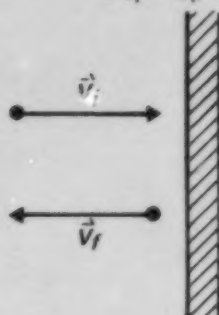
- Haber-Schaim, 4th ed., p. 201.
Ingram, Part 1, pp. 225, 226.
Mayfield, Book 1, pp. 21, 22.
Williams, p. 57.

22 Correct Response: D

Discussion:

Change in velocity = final velocity - initial velocity

$$= v_f - v_i$$



To subtract the 1000 m s^{-1} eastwards, an opposite velocity must be added, that is, 1000 m s^{-1} westwards, to the final velocity. This gives
 1000 m s^{-1} west + 1000 m s^{-1} west
 $= 2000 \text{ m s}^{-1}$ west.

References:

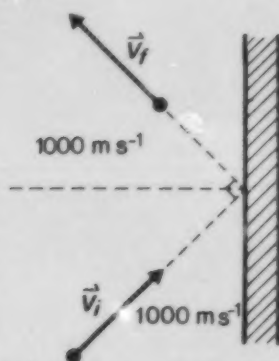
Haber-Schaim, 4th ed., p. 205.

Ingram, Part 1, p. 25.

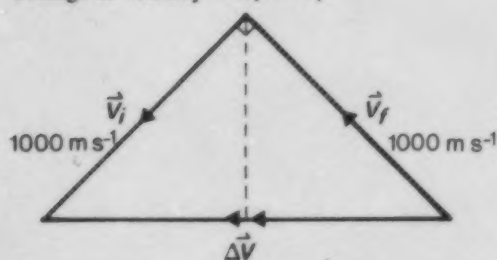
Mayfield, Book 1, p. 22.

23 Correct Response: B

Discussion:



$$\text{Change in velocity} = \vec{v}_f - \vec{v}_i$$



$$\begin{aligned} \Delta v^2 &= 1000^2 + 1000^2 \\ &= 2 \times 1000^2 \end{aligned}$$

$$\begin{aligned} \Delta v &= 1000 \times 1.414 \\ &= 1414 \text{ m s}^{-1} \text{ west.} \end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 205.

Ingram, Part 1, p. 25.

Mayfield, Book 1, p. 22.

24 Correct Response: C

Discussion:

The velocity of Q relative to P is obtained by subtracting the velocity of P from the velocity of Q .

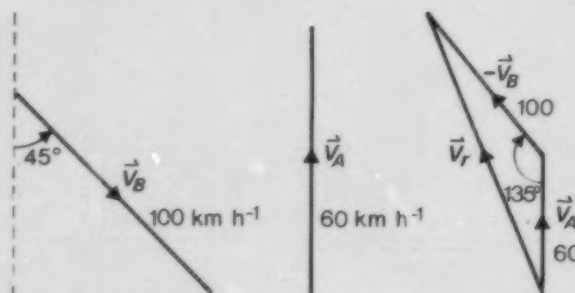
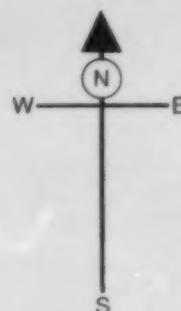
That is, $\vec{v}_q - \vec{v}_p$.

References:

Ingram, pp. 30, 31.

25 Correct Response: B

Discussion:



To find the velocity of A relative to B , we subtract $\vec{v}_B$ from $\vec{v}_A$.

A scale diagram can be drawn to measure $\vec{v}_R$, or

the value of $\vec{v}_R$ can be found using the cosine rule —

$$\begin{aligned} v_R^2 &= 60^2 + 100^2 - 2 \times 60 \times 100 \times \cos 135^\circ \\ &= 3600 + 10\,000 - 12\,000 (-\cos 45^\circ) \\ &= 13\,600 + 8520 \\ &= 22\,120 \end{aligned}$$

$$v_R = 148.7 \text{ km h}^{-1}$$

Alternatively, it could be reasoned that the speed of car A relative to car B would be slightly less than 160 (the result if both cars were travelling in exactly opposite directions), and hence, **B** could be selected as the most likely result.

References:

Ingram, Part 1, pp. 30, 31.

- 26-28 Correct Responses: 26 A
27 C
28 D

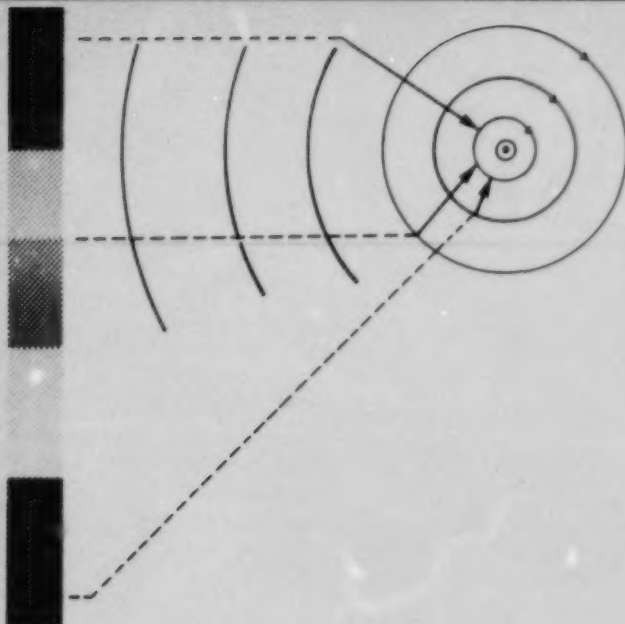
Discussion:

The following discussion refers to the points of the compass to indicate direction.

- 26 Since, relative to the earth, G is travelling at speed v in a westerly direction, then observer G would see M moving at the same speed in an easterly direction. Hence vector I is the velocity of M relative to G at this instant.
- 27 At that instant, an observer at M will see B travelling in a southerly direction. Since B is half way between centre and rim of the merry-go-round, his speed will be half that at the rim, that is, $\frac{v}{2}$.
- 28 B is not moving relative to G , since both B and G are at rest relative to the merry-go-round.

References:

Haber-Schaim, 4th ed., p. 212.
Ingram, Part 1, p. 30.
Mayfield, Book 1, p. 3.
Project Physics, Unit 1, p. 105.



Diagnostic Aid 3 Motion in one dimension

Description

This diagnostic aid is one of a collection of 21 diagnostic aids corresponding to the 21 separate tests in the *Physics Unit Tests*.

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To gain maximum benefit from the *Physics Unit Tests* weaknesses diagnosed need to be followed up. These diagnostic aids make it possible for you to proceed with this follow up in your own time. If you do not understand the discussion you are advised to seek help from your teacher.

References

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- Haber-Schaim: Haber-Schaim, U., Cross, J.B., Dodge, J.H., and Walter, J.A. *PSSC Physics*. 4th ed. Lexington, Mass.: D.C. Heath, 1976. (Reference is also made to 3rd ed.)
- Ingram: Ingram, A.D., Kuhl, D.H., McCarthy, I.E., Sandercock, E.R., Smith, W.F., and Waite, P.J. *Physics: A Laboratory-oriented Approach*. (Study Guide Leaving Part 1, Study Guide Matriculation Part 2). Adelaide: Rigby, 1971, 1972.
- Mayfield: Mayfield, J.M. Parham, R.T., and Webber, B.J. *Fundamentals of Senior Physics*. (Book 1, Book 2). Melbourne: Heinemann Educational Australia Pty Ltd, 1973.
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- Williams: Williams, J.E., Trinklei, F.E., Metcalfe, H.C., and Lefler, R.W. *Modern Physics*. New York: Holt, Rinehart, & Winston, 1976.

The Australian Council for Educational Research Limited thanks the following publishers for donating textbooks used in referencing the aids: Heinemann Educational Australia Pty Ltd, Richmond, Victoria, for *Fundamentals of Senior Physics*. Rigby Limited, Box Hill, Victoria, for *Physics: A Laboratory-oriented Approach*.

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- 1-4 Correct responses: 1 D
2 D
3 A
4 B

Discussion:

- 1 D is correct because a vector can neither increase nor decrease; only its magnitude can increase or decrease. A vector implies both direction and magnitude.
- 2 Describing the speed of the ball is similar to describing its velocity as in item 1, but now no account of the direction of travel would be taken. Thus the speed at first is decreasing, then after the highest point, is increasing.
- 3 and 4 At all points in the flight of the ball, the acceleration is the acceleration due to gravity, since it is stated in the questions that air resistance is to be neglected. This acceleration due to gravity is downwards in direction, and equal in magnitude to the value of g at the place.

It is important to remember that the acceleration is determined by what forces are acting and on the mass of the object, and that acceleration does not depend on velocity. Even at the highest point in the path, where momentarily the velocity is zero, the acceleration remains the same magnitude and direction as at all times in the flight.

References:

Haber-Schaim, 4th ed., p. 245.
Ingram, Part 1, pp. 21-24.
Mayfield, Book 1, p. 26.
Project Physics, Unit 1, pp. 83-85.
Williams, pp. 90-92.

- 5 and 6 Correct Responses: 5 C
6 B

Discussion:

- 5 If air resistance can be neglected, the ball falls with constant downward acceleration of magnitude g (taken to be 10 m s^{-2}).

Starting with zero velocity, and taking 3.0 s to fall, the distance fallen ' S ' will be:

$$S = 0 + \left(\frac{1}{2} \times 10 \times (3.0)^2\right) \\ = 45 \text{ m.}$$

- 6 With initial velocity zero, acceleration 10 m s^{-2} , and time of fall 3.0 s the final velocity at the end of this time will be:

$$v = 0 + (10 \times 3.0) \\ = 30 \text{ m s}^{-1}.$$

References:

Haber-Schaim, 4th ed., p. 245.
Ingram, Part 1, pp. 21-24.
Mayfield, Book 1, pp. 26, 27.
Project Physics, Unit 1, pp. 83-85.
Williams, pp. 87-92.

- 7-10 Correct Responses: 7 E
8 C
9 D
10 C

Discussion:

- 7 Cyclist V remained at zero displacement (still in the town) until the 10 minute mark. All others were at some displacement from the town by that time.
- 8 The speed can be determined by finding the gradient of a displacement-time graph. The steepest gradient of displacement-time graph will therefore indicate the greatest speed, and on the given graphs the steepest gradient is that portion for cyclist III between times 20 and 30 minutes.
- 9 Stationary periods are shown on the displacement-time graphs as portions with zero gradient (indicating zero velocity). One could also see that a horizontal portion of displacement-time graph shows a period of time when displacement did not change—the object must therefore have been at rest. Such horizontal sections of graph appear for part of the time for cyclists III and V, and cyclist IV was stationary all the time.
- 10 The graphs show that two of the cyclists were not at the town at time $t = 0$. Cyclist I was 2 km from the town, and cyclist IV was 3 km away. However only one of those cyclists appears in the list of possible answers to item 10, namely cyclist IV.

References:

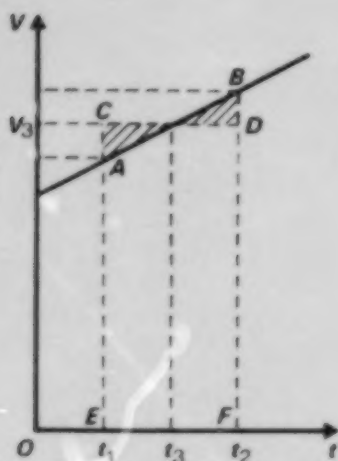
Haber-Schaim, 4th ed., p. 175.
Ingram, Part 1, pp. 10-14.
Mayfield, Book 1, pp. 7, 8.
Project Physics, Unit 1, pp. 18-21.
Williams, pp. 73-75.

- 11 and 12 Correct Responses: 11 A
12 A

Discussion:

- 11 One can define the meaning of average speed to be given by dividing the total distance covered by the time taken. This is true irrespective of what kind of motion is taking place. Statement I thus holds true.

- 12 Statement I holds true for motion with constant acceleration, as well as for other types of motion.



If the object has constant acceleration, the graph of velocity vs. time will be a straight line.

The distance travelled in the time interval t_1 to t_2 is given by the area $ABFE$, but this is the same area as the rectangle $CDFE$, and hence the velocity v_3 , which is the velocity at time t_3 , midway between t_1 and t_2 , must be the average velocity. Hence Statement III is true in this case too.

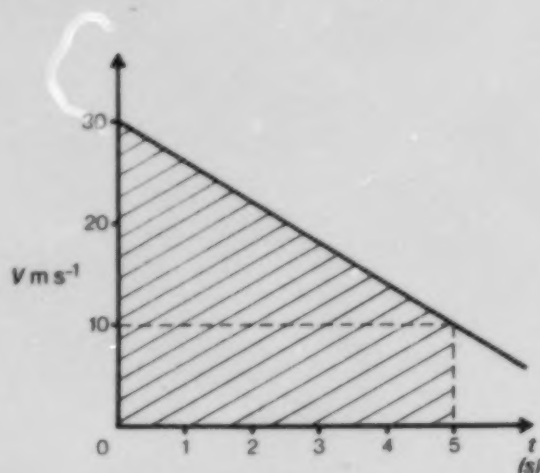
Note: For statement II to be true, the speed would have to remain *constant* at all times in the period concerned. Statement IV would be true for motion with constant acceleration only if the speed was zero at the start of the time interval concerned.

References:

Haber-Schaim, 4th ed., pp. 175, 185.
Ingram, Part 1, pp. 10, 11, 21.
Mayfield, Book 1, pp. 8–12.
Project Physics, Unit 1, pp. 15–17.
Williams, pp. 73–75.

- 13 and 14 Correct Responses: 13 C
14 B

Discussion:



- 13 The acceleration is given by the gradient of a velocity-time graph, and can be calculated from the figure as:

$$\begin{aligned} a &= -\frac{(30 - 10)}{5} \\ &= -\frac{20}{5} \\ &= -4 \text{ m s}^{-2} \end{aligned}$$

- 14 Displacement from $t = 0$ to $t = 5$ s is given by the area under the velocity-time graph in that period of time.

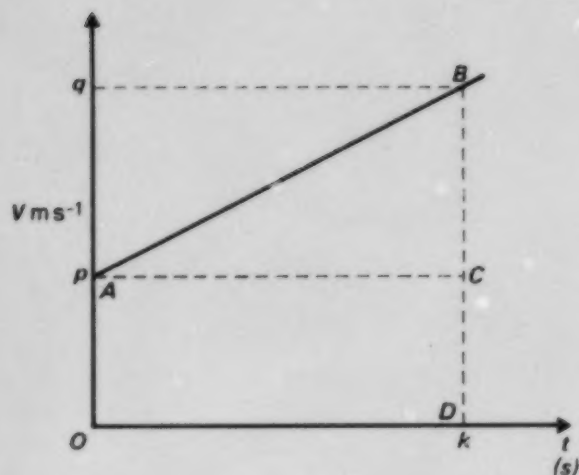
$$\begin{aligned} s &= (10 \times 5) + \left(\frac{1}{2} \times 20 \times 5\right) \\ &\quad \text{(rectangle)} \quad \text{(triangle)} \\ &= 50 + 50 \\ &= 100 \text{ m.} \end{aligned}$$

References:

Haber-Schaim, 4th ed., pp. 181, 185.
Ingram, Part 1, pp. 18–21.
Mayfield, Book 1, pp. 11, 12.
Project Physics, Unit 1, p. 29.
Williams, pp. 85, 86.

15 Correct Response: C

Discussion:



The body described in the question moves in a way described by this velocity-time graph. Note that the graph is a straight line because the motion has constant acceleration. The gradient of this graph is r , equal to the acceleration.

In the time interval from 0 to k seconds, the increase in velocity is given by BC on the graph which equals kr .

Therefore $q = p + kr$ (i)

Thus equation I is wrong, since it interchanges p and q . The distance travelled in time interval 0 to k seconds is given on the graph by the area $ABDO$.

Thus $f = \text{area } ABDO$
 $= \text{area } ACDO + \text{area } ABC$
 $= (p \times k) + \frac{1}{2} (q - p) k$
 $= pk + \frac{1}{2} qk + \frac{1}{2} pk$
 $= \frac{1}{2} pk + \frac{1}{2} qk$
 $f = \frac{1}{2} k (p + q)$ (ii)

Thus equation III is correct.

From (i) we can substitute $(p + kr)$ for q in equation (ii), giving

$$f = \frac{1}{2} pk + \frac{1}{2} k (p + kr)$$

$$= \frac{1}{2} pk + \frac{1}{2} pk + \frac{1}{2} k^2 r$$

$$f = pk + \frac{1}{2} k^2 r$$
 (iii)

Thus equation II is correct.

Equation (i) can be re-arranged to give:

$$kr = q - p$$

$$k = \frac{q - p}{r}$$

Substituting this expression for k in equation (ii), results in the following:

$$f = \frac{1}{2} \frac{(q - p)}{r} \times (q + p)$$

$$= \frac{(q^2 - p^2)}{2r}$$

$$2rf = q^2 - p^2$$

$$q^2 = p^2 + 2rf$$

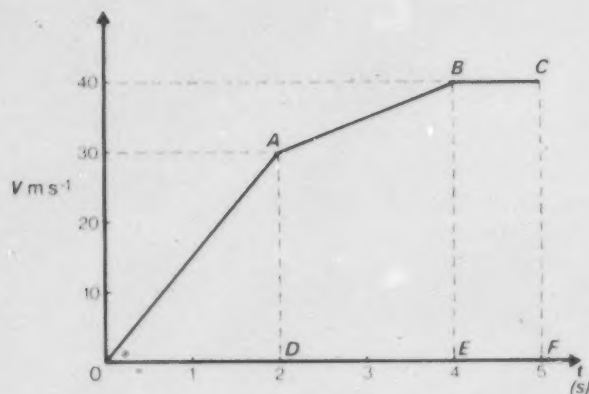
Thus equation IV is not correct, as it replaces f by k in the last term.

References:

- Haber-Schaim, 4th ed., p. 188.
- Ingram, Part 1, pp. 21, 22.
- Mayfield, Book 1, pp. 14, 15.
- Project Physics, Unit 1, p. 50.
- Williams, pp. 87-90.

- 16, 17 and 18 Correct Responses: 16 B
17 B
18 A

Discussion:



- 16 Distance travelled from $t = 0$ to $t = 2$ s

$$= \text{area of figure } OAD \\ = \frac{1}{2} \times (30) \times (2) \text{ m} \\ = 30 \text{ m.}$$

- 17 Distance travelled from $t = 2$ to $t = 4$ s

$$= \text{area of figure } ABED \\ = (30 \times 2) + \left(\frac{1}{2} \times 10 \times 2\right) \\ = 60 + 10 \text{ m} \\ = 70 \text{ m.}$$

Hence total distance travelled from $t = 0$ to $t = 4$ s

$$= 30 + 70 \text{ m} \\ = 100 \text{ m.}$$

- 18 Acceleration at $t = 3$ s is given by gradient of portion AB of graph

$$= \frac{(40 - 30) \text{ m s}^{-1}}{(4 - 2) \text{ s}} \\ = \frac{10}{2} \text{ m s}^{-2} \\ = 5 \text{ m s}^{-2}$$

References:

Haber-Schaim, 4th ed., pp. 181, 185.
Ingram, Part 1, pp. 18–21.
Mayfield, Book 1, p. 12.
Williams, p. 86.

- 19 and 20 Correct Responses: 19 B
20 A

Discussion:

- 19 Average speed during first second

$$\frac{\text{distance travelled}}{\text{time taken}}$$

$$= \frac{6.0}{1.0} \text{ m s}^{-1} \\ = 6.0 \text{ m s}^{-1}.$$

Similarly, average speed during third second

$$= 16.0 \text{ m s}^{-1}.$$

Since the ball is uniformly accelerated, the average speed in the second second must be half way between these values, that is 11.0 m s^{-1} .

- 20 Acceleration = $\frac{\text{change of velocity}}{\text{time interval}}$
$$= \frac{(16.0 - 6.0)}{2} \text{ m s}^{-2} \\ = 5.0 \text{ m s}^{-2}.$$

References:

Haber-Schaim, 4th ed., p. 185.
Ingram, Part 1, pp. 21–23.
Mayfield, Book 1, pp. 9, 11.
Project Physics, Unit 1, p. 29.
Williams, pp. 73–75; pp. 85, 86.

- 21 Correct Response: D

Discussion:

From the given acceleration-time graph, it can be seen that there is a constant, negative acceleration. The velocity-time graph must therefore have a constant, negative gradient. Hence both I and III are acceptable graphs.

References:

Haber-Schaim, 4th ed., p. 185.
Ingram, Part 1, p. 18.
Project Physics, Unit 1, p. 29.

**22 and 23 Correct Responses: 22 C
23 B**

Discussion:

- 22 Distance travelled from $t = 0$ to $t = 4$ s is given by the area beneath the velocity-time graph, which is a little less than 10 squares. From the scales on the axes, the area of one square

$$= (4 \text{ cm s}^{-1}) \times (1 \text{ s}) \\ = 4 \text{ cm.}$$

Hence distance is a little less than 40 cm.

- 23 Sketching a tangent to the curve at the point where $t = 6$ s, the gradient is found to be approximately 1.8 cm s^{-2} .

References:

Haber-Schaim, 4th ed., pp. 181, 185.
Ingram, Part 1, pp. 11, 12.
Mayfield, Book 1, pp. 11, 12.
Project Physics, Unit 1, pp. 28–30.

24 Correct Response: D

Discussion:

If the second set of photographs is to represent an acceleration $2a$, then the velocity changes in each time interval should be twice as great as the velocity changes in the original photo.

Hence for each time interval, there should be twice the distance between images in the second photograph as in the first. Thus photograph D is required.

25 Correct Response: C

Discussion:

If the second tape represents constant speed $2v$, there must be equal spacing between dots, that spacing being twice as great as in the original. Hence C is the required diagram.

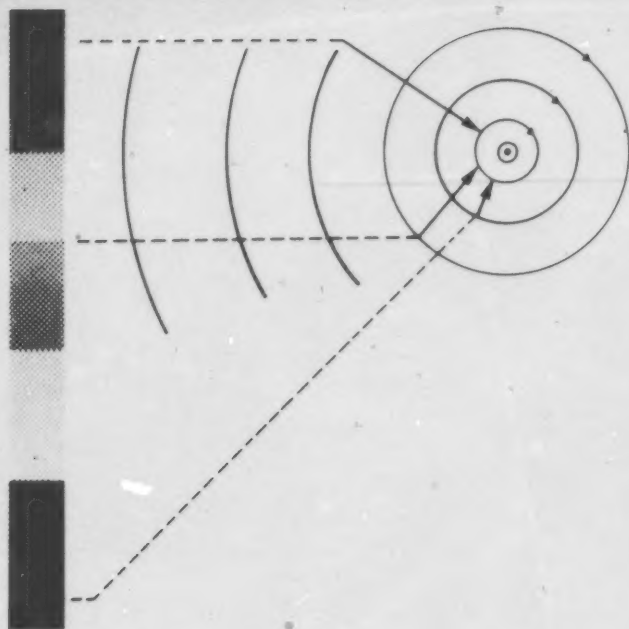
**26 and 27 Correct Responses: 26 D
27 A**

Discussion

- 26 Constant velocity will produce marks equally spaced along the tape. This occurs in sections I, III and V only.
- 27 Greatest acceleration is indicated when the spacing between adjacent dots is increasing or decreasing most rapidly. This occurs in section II of the tape.

References:

Project Physics, Unit 1, pp. 13–15, 28–30.



Diagnostic Aid 4 Motion on a plane

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1 Correct Response: B**Discussion:**

For uniform circular motion, the instantaneous velocity is tangential to the circular path. The direction of the force however is radially towards the centre. Hence, it can be seen that the direction of the force is at right angles to the direction of the instantaneous velocity for uniform circular motion. If either A, C or D were selected as the correct response, then the formula

$$F = \frac{mv^2}{r}$$

should be referred to.

References:

Haber-Schaim, 4th ed., p. 211.
Ingram, Part 1, p. 75.
Mayfield, Book 1, p. 46.
Project Physics, Unit 1, p. 109.
Williams, pp. 110-112.

2 Correct Response: D**Discussion:**

Again, for uniform circular motion the speed is constant, the direction of the velocity is tangential to the circular path and the magnitude of the acceleration is constant. However, the direction of acceleration is radially towards the centre. Alternative D is therefore the correct response.

References:

Haber-Schaim, 4th ed., p. 211.
Ingram, Part 1, p. 75.
Mayfield, Book 1, pp. 30, 46.
Project Physics, Unit 1, p. 107.
Williams, p. 112.

3 Correct Response: C**Discussion:**

Frequency is defined as the number of cycles per second. In this example, the object completes $\frac{1}{6}$ of a cycle in 0.6 seconds and therefore in 0.1 second it completes $\frac{1}{6 \times 6}$ cycles.

Hence, in 1 second, it completes $\frac{10}{6 \times 6}$ cycles

that is $\frac{5}{18}$, alternative C.

Alternative B is the period of the revolution which is the reciprocal of the frequency.

References:

Haber-Schaim, 4th ed., p. 211.
Ingram, Part 1, p. 26.
Mayfield, Book 2, p. 56.
Project Physics, Unit 1, p. 107.

4 Correct Response: A**Discussion:**

Speed is defined as $\frac{\text{distance travelled}}{\text{time taken}}$.

In this example, the object travels $\frac{1}{6}$ of the circumference in 0.6 seconds.

$$\begin{aligned} \text{but } \frac{1}{6} \text{ of circumference} &= \frac{1}{6} \times 2\pi r \\ &= \frac{1}{6} \times 2 \times \pi \times 0.8 \\ \text{hence speed} &= \frac{1}{6} \times 2 \times \pi \times 0.8 \times \frac{1}{0.6} \\ &= \frac{4\pi}{9} \end{aligned}$$

Alternatively, this can be found from the previous question since

$$\begin{aligned} v &= 2\pi r f \\ &= 2 \times \pi \times 0.8 \times \frac{5}{18} \\ &= \frac{4\pi}{9} \end{aligned}$$

References:

Haber-Schaim, 4th ed., pp. 211, 212.
Ingram, Part 1, p. 26.
Mayfield, Book 1, p. 9, (2) p. 56.
Project Physics, Unit 1, p. 108.
Williams, pp. 110, 111.

5 Correct Response: B**Discussion:**

As the two objects are fixed to the turntable they must be rotating at the same frequency. The ratio is therefore 1:1.

References:

Haber-Schaim, 4th ed., p. 211.
Ingram, Part 1, p. 26.
Mayfield, Book 2, p. 56.
Project Physics, Unit 1, p. 107.

6 Correct Response: A**Discussion:**

$$\text{Speed} = \frac{\text{distance travelled}}{\text{time interval}}$$

or alternatively,

$$\text{Speed} = \frac{\text{distance travelled in one cycle}}{\text{time for one cycle (i.e. period)}}$$

$$\text{Now frequency} = \frac{1}{\text{period}}$$

$$\text{hence speed} = \text{distance travelled in one cycle} \times \text{frequency}$$

$$\text{Thus, } \frac{\text{speed } X}{\text{speed } Y} = \frac{2\pi r_x f_x}{2\pi r_y f_y}$$

where r_x is distance from X to centre of the turntable, and r_y is distance from Y to centre of the turntable and f_x, f_y are the frequencies of X and Y respectively. So, since $f_x = f_y$ (see item 5), then

$$\begin{aligned} \frac{\text{speed of } X}{\text{speed of } Y} &= \frac{r_x}{r_y} \\ &= \frac{0.1}{0.2} \\ &= \frac{1}{2} \end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 211.
Ingram, Part 1, p. 26.
Mayfield, Book 1, p. 30.
Project Physics, Unit 1, p. 108.
Williams, pp. 110, 111.

7 Correct Response: A**Discussion:**

$$\text{Centripetal acceleration can be defined as } a = \frac{v^2}{r}$$

where v = speed of object, and
 r = radius of circular path

$$\text{thus } \frac{a_x}{a_y} = \frac{v_x^2/r_x}{v_y^2/r_y} = \left\{ \frac{v_x}{v_y} \right\}^2 \frac{r_y}{r_x}$$

$$\text{but } \frac{v_x}{v_y} = \frac{1}{2} \text{ (see item 6)}$$

$$\begin{aligned} \text{thus } \frac{a_x}{a_y} &= \left\{ \frac{1}{2} \right\}^2 \times \frac{0.2}{0.1} \\ &= \frac{1}{2} \times \frac{1}{2} \times \frac{2}{1} \\ &= \frac{1}{2} \end{aligned}$$

Alternatively, the following formula could be used

$$a = 4\pi^2 f^2 r$$

References:

Haber-Schaim, 4th ed., p. 212.
Ingram, Part 1, p. 28.
Mayfield, Book 1, p. 30.
Williams, p. 111.

8 Correct Response: A**Discussion:**

By Newton's Second Law, force can be defined as

$$F = ma$$

$$\text{thus } \frac{F_x}{F_y} = \frac{m_x a_x}{m_y a_y} = \left\{ \frac{m_x}{m_y} \right\} \times \left\{ \frac{a_x}{a_y} \right\}$$

but $m_x = m_y$ (coins identical)

$$\text{and } \frac{a_x}{a_y} = \frac{1}{2} \text{ (item 7)}$$

$$\text{hence } \frac{F_x}{F_y} = 1 \times \frac{1}{2} = \frac{1}{2}$$

References:

Haber-Schaim, 4th ed., p. 252.
Ingram, Part 1, p. 75.
Mayfield, Book 1, p. 46.
Project Physics, Unit 1, p. 109.
Williams, p. 112.

9 Correct Response: E**Discussion:**

The only variable altered by changing the speed of rotation is the frequency. However, the ratio of frequencies still remains 1, hence none of the ratios will be different.

References:

Haber-Schaim, 4th ed., p. 252.
Ingram, Part 1, pp. 26-28.
Mayfield, Book 2, p. 56.
Project Physics, Unit 1, p. 108.
Williams, pp. 110-112.

10 Correct Response: C

Discussion:

Acceleration for circular motion is given by $a = \frac{v^2}{r}$

(see item 7)

$$\text{but } v = \frac{\text{distance}}{\text{time}} = \frac{\text{circumference}}{\text{time for one lap}} = \frac{c}{t}$$

$$\text{Now } c = 2\pi r$$

$$\text{hence } \frac{1}{r} = \frac{2\pi}{c}$$

$$\text{Consequently } a = \frac{v^2}{r} = \frac{(c/t)^2}{r} = \frac{c^2}{t^2} \times \frac{1}{r} \\ = \frac{c^2}{t^2} \times \frac{2\pi}{c}$$

Substitution of the given values leads to

$$a = \frac{200}{20 \times 20} \times 2\pi \\ = \pi$$

Alternatively, the other definition of acceleration,

$$\text{viz } a = \frac{4\pi^2 R}{T^2}$$

could be used.

References:

Haber-Schaim, 4th ed., p. 211.

Ingram, Part 1, p. 28.

Mayfield, Book 1, p. 30.

Project Physics, Unit 1, pp. 109, 110.

Williams, p. 111.

11 Correct Response: B

Discussion:

The frictional force referred to is that which causes the change in direction and as such is given by

$$F (\text{N}) = M (\text{kg}) \times a (\text{m/s}^2)$$

$$\text{hence, } F = \frac{mv^2}{r} \\ = \frac{500 \times 6.0 \times 6.0}{50} \\ = 360 \text{ N}$$

References:

Haber-Schaim, 4th ed., p. 252.

Ingram, Part 1, p. 75.

Mayfield, Book 1, p. 46.

Project Physics, Unit 1, p. 109.

Williams, p. 112.

12 and 13 Correct Responses: 12 D

13 D

Discussion:

- 12** The diagram below shows the forces acting on the bob in its lowest position.

This leads to the equation



$$T - W = ma$$

$$\text{hence } T = ma + W$$

$$\text{where } a = \frac{v^2}{r} \text{ and } W = mg$$

$$\text{thus } T = 4.0 \times \frac{(3.0)^2}{1.5} + 4.0 \times 10$$

$$= 24 + 40$$

$$= 64 \text{ N}$$

- 13** The resultant force is always towards the centre of the circle and hence in direction IV.

References:

Haber-Schaim, 4th ed., p. 261.

Ingram, Part 1, p. 75.

Mayfield, Book 2, pp. 65, 66.

Williams, pp. 112, 113.

14 and 15 Correct Responses: 14 B

15 C

Discussion:

- 14** Under the conditions given, the velocity changes direction and hence sign, going from a positive value down to zero and then increasing in magnitude but in the negative direction. The graph in alternative B depicts the situation.
- 15** The magnitude and direction of the acceleration is that due to gravity and is always constant with a negative value (alternative C).

References:

Haber-Schaim, 4th ed., pp. 180, 181.

Ingram, Part 1, pp. 70, 116.

Mayfield, Book 1, p. 37.

Williams, pp. 109, 110.

16-20 Correct Responses: 16 B

17 B

18 A

19 A

20 D

Discussion:

Under the conditions stated, once the sphere had been projected, there was no horizontal force, only a vertical force acting on the sphere. Consequently, there is no acceleration in the horizontal direction.

- 16 From the graph, it can be seen that the sphere travels in a horizontal direction, a distance 0.3 m per time interval. Thus at time 4T, the sphere will be at a distance 1.20 m (alternative B).

- 17 With the first edition of Test 4, the vertical positions 2T, 3T and 5T of the sphere have been incorrectly marked.

Interpolation of the graph gives a value of 1.00 m (alternative B) for the y value of the sphere's position at the end of the fourth time interval.

The correct value is 1.60 m, which can be obtained with the following method:

$$\begin{aligned}
 S &= \frac{1}{2} g t^2 \\
 \text{hence } S_{1T} &= \frac{1}{2} g (1T)^2 \\
 \text{and } S_{4T} &= \frac{1}{2} g (4T)^2 \\
 \text{thus } \frac{S_{1T}}{S_{4T}} &= \frac{\frac{1}{2} g T^2}{\frac{1}{2} g 16 T^2} = \frac{1}{16} \\
 \therefore S_{4T} &= 16 S_{1T} = 16 \times 0.1 = 1.60 \text{ m.}
 \end{aligned}$$

- 18 The average velocity of the sphere is calculated from $\frac{\text{total distance}}{\text{time interval}}$

Thus for the third time interval for first edition tests, the average velocity is

$$\frac{0.30}{1T} = 0.30 \text{ m per time interval,}$$

that is, alternative A.

However, for later reprints of the test, the y co-ordinates for positives 2T and 3T are 0.40 m and 0.90 m respectively.

Hence average velocity for third time interval is 0.50 m per time interval.

- 19 As indicated earlier there is no horizontal component of the net force hence alternative A is the correct response.
- 20 The vertical component of the net force is constant throughout and is equal to its weight, that is 10 M (alternative D).

References:

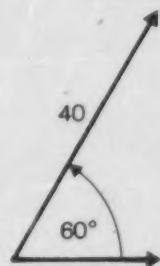
Haber-Schaim, 4th ed., p. 248.
Ingram, Part 1, pp. 28, 29, 116.
Mayfield, Book 1, pp. 26-28.
Project Physics, Unit 1, p. 101.
Williams, pp. 109, 110.

- 21-25 Correct Responses: 21 A
22 C
23 C
24 B
25 D

Discussion:

Once the stone is thrown the only force acting on it is the gravitational force. Thus at its maximum height its vertical velocity will be zero, (alternative A, item 21), and its acceleration g, towards the earth (alternative C, item 22).

The horizontal component of the velocity is constant throughout and is given by:



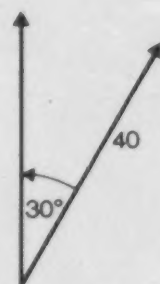
horizontal component

$$40 \cos 60^\circ, \text{ that is } 20 \text{ m s}^{-1}$$

(alternative C, item 23).

In response to item 24 the answer is again 10 m s^{-1} down, as the only force acting is gravity (alternative B).

- 25 Immediately prior to impact the magnitude of the vertical component of the downward velocity will be equal to the magnitude of the vertical component of the initial velocity



vertical component

$$\begin{aligned}
 \text{i.e.: } &40 \cos 30^\circ \text{ (or } 40 \sin 60^\circ) \\
 &\text{or } \frac{40\sqrt{3}}{2} \\
 &= 20\sqrt{3} \text{ (alternative D).}
 \end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 248.
Ingram, Part 1, pp. 28, 29.
Mayfield, Book 1, pp. 26-28.
Project Physics, Unit 1, p. 101.
Williams, pp. 109, 110.

26 Correct Response: C**Discussion:**

The general statement that acceleration is at right angles to the direction of motion can only be made in reference to uniform circular motion. Similarly, the statement that acceleration is directly proportional to the square of the instantaneous velocity is also only true for uniform circular motion. The correct response is alternative C, since the magnitude of the acceleration is constant for both motions.

If A were selected then it has been forgotten that acceleration is a vector and hence both magnitude and direction must not change for the acceleration to be constant.

References:

Haber-Schaim, 4th ed., p. 248.
Ingram, Part 1, pp. 26–29.
Mayfield, Book 1, pp. 26–29.
Williams, pp. 109–112.

27–29 Correct Responses: 27 C**28 D****29 D****Discussion:**

This situation is similar to that in items 16 to 20. Since there is no horizontal force there is no horizontal acceleration. Alternative C is the correct response to item 27.

28 The brick, on leaving the boy's hand, is falling freely under gravity and so the acceleration is constant but not zero (alternative D).

29 As there is no horizontal force acting on the brick the horizontal velocities of the brick and the hand will be the same. Therefore the brick will remain vertically below the hand. The brick however, will accelerate vertically and so go further in a given time period, as time passes. The strip that indicates these two conditions is D.

References:

Haber-Schaim, 4th ed., p. 248.
Ingram, Part 1, p. 28, 29.
Mayfield, Book 1, p. 26–28.
Project Physics, Unit 1, p. 101.
Williams, pp. 109, 110.

30 Correct Response: B**Discussion:**

Only the vertical component of the motion needs to be considered. Initially, the stone has no vertical velocity, it accelerates at 10 m s^{-2} and takes 5 s to reach the ground. The distance can be calculated using the following relationship:

$$s = ut + \frac{1}{2}at^2$$

where s = distance

u = initial velocity

a = acceleration

and t = time taken

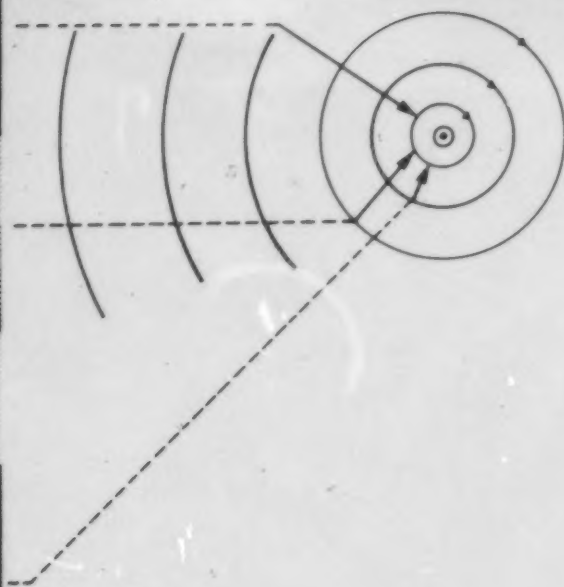
Substituting the relevant values gives

$$s = \frac{1}{2} \times 10 \times 5^2$$

= 125 m.

References:

Haber-Schaim, 4th ed., p. 248.
Ingram, Part 1, pp. 28, 29.
Mayfield, Book 1, pp. 26–28.
Williams, pp. 109, 110.



Diagnostic Aid 5 Dynamics

Description

This diagnostic aid is one of a collection of 21 diagnostic aids corresponding to the 21 separate tests in the *Physics Unit Tests*.

In each diagnostic aid an explanation is provided so that the reasons why the responses are correct or incorrect are available to you.

To gain maximum benefit from the *Physics Unit Tests* weaknesses diagnosed need to be followed up. These diagnostic aids make it possible for you to proceed with this follow up in your own time. If you do not understand the discussion you are advised to seek help from your teacher.

References

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- Ingram:** Ingram, A.D., Kuhl, D.H., McCarthy, I.E., Sandercock, E.R., Smith, W.F., and Waite, P.J. *Physics: A Laboratory-oriented Approach*. (Study Guide Leaving Part 1, Study Guide Matriculation Part 2). Adelaide: Rigby, 1971, 1972.
- Mayfield:** Mayfield, J.M. Parham, R.T., and Webber, B.J. *Fundamentals of Senior Physics*. (Book 1, Book 2). Melbourne: Heinemann Educational Australia Pty Ltd, 1973.
- Project Physics:** *Project Physics Course: Programmed Instruction Books* (Kinetic Molecular Theory of Gases, Waves 1-2, Equations 1-3, Vectors 1-3); *Text and Handbook* (Units 1-6). Sydney: Martin Educational, 1970.
- Williams:** Williams, J.E., Trinklei, F.E., Metcalfe, H.C., and Lefler, R.W. *Modern Physics*. New York: Holt, Rinehart, & Winston, 1976.

The Australian Council for Educational Research Limited thanks the following publishers for donating textbooks used in referencing the aids: Heinemann Educational Australia Pty Ltd, Richmond, Victoria, for *Fundamentals of Senior Physics*. Rigby Limited, Box Hill, Victoria, for *Physics: A Laboratory-oriented Approach*.

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1 and 2 Correct Responses: 1 C
2 D

Discussion:

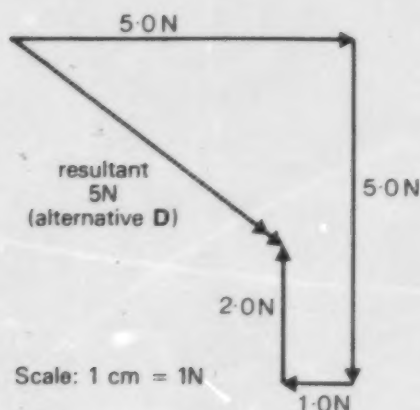
Since force is a vector quantity, items 1 and 2 must be answered using vector analysis. Two approaches are possible in finding a solution to these items:

- (i) Draw scale diagrams of vector addition, or
- (ii) resolve each force into the required direction.

In item 1, there are only two forces which have a component to the right, namely the 1.0 N and 5.0 N forces. Combining these two we get

$$5.0 + (-1.0) = 4.0 \text{ (alternative C)}$$

Item 2 is done below using a scale diagram. Since it is required to find the overall net force on the body, not just the force in a particular direction, all forces must be considered.



An alternative approach is as follows:

- (i) net force to right = 4 N
- (ii) net force down = 3 N, therefore
- (iii) overall net force is 5 N,

the hypotenuse of a 3,4,5 right angle triangle.

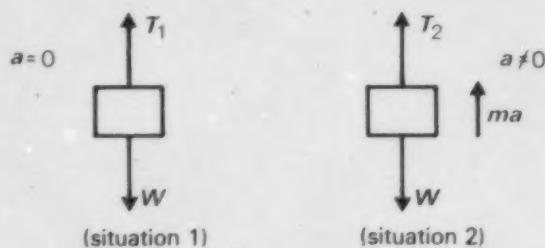
References:

Haber-Schaim, 4th ed., pp. 202, 237.
Ingram, Part 1, pp. 224-226.
Mayfield, Book 1, pp. 20, 21.
Project Physics, Unit 1, p. 73.
Williams, pp. 49, 50.

3 and 4 Correct Responses: 3 C
4 B

Discussion:

Diagrams 1 and 2 show the forces acting on the mass in each situation.



The equations of motion are:

$$\text{Situation 1 } T_1 - W = 0 \Rightarrow T_1 = W$$

$$\text{Situation 2 } T_2 - W = ma \Rightarrow T_2 = W + ma$$

The tension in situation 2 is greater than in situation 1 (alternative C, item 3).

The force of gravity will be the same in each situation. It would only change if the situations were located at considerably different heights above the earth.

References:

Haber-Schaim, 4th ed., p. 235.
Mayfield, Book 1, p. 45.
Project Physics, Unit 1, p. 86.

5 and 6 Correct Responses: 5 C
6 B

Discussion:

As each individual rubber band is stretched the same distance, the same force must be applied to each. In situation I, the force applied to the hook is that of 'one stretched rubber band'. The second rubber band is stretched by the first. In situation II the force on the hook is from 'two stretched rubber bands' and thus twice the value of F_1 (alternative C, item 5).

In item 6, F_2 stretches the first rubber band which in turn stretches the second the same amount. As the bands are in series, $F_2 = F_1$ (alternative B).

Reference:

Haber-Schaim, 4th ed., p. 235.

7 Correct Response: A

Discussion:

Action-reaction forces apply to the same objects. That is, if the action is between the box and the floor, then so must the reaction be between the box and the floor. In addition, they are in opposite directions. Thus as the weight of the box, the 'action', acts downwards, the reaction must act upwards and is the force of the floor on the box.

References:

Haber-Schaim, 4th ed., p. 318.
Ingram, Part 1, pp. 73, 74.
Mayfield, Book 1, pp. 43, 44.
Project Physics, Unit 1, p. 86.
Williams, p. 99.

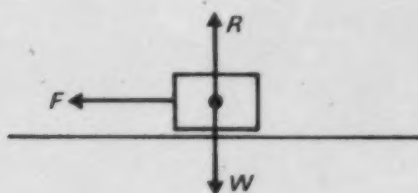
8-10 Correct Responses: 8 A

9 D

10 A

Discussion:

For the following explanations refer to the diagram below.



Here, F = horizontal force

W = weight force

and R = reaction force

Horizontally, net force (N) = mass (kg) $\times$ acceleration (m s^{-2})

that is, $F = ma$

$$\frac{F}{m} = a$$

(alternative A, item 8)

Now, weight (N) = mass (kg) $\times$ gravitational field strength (N kg^{-1})

so $W = mg$

(alternative D, item 9)

The vertical force of the table on the box is simply the reaction force (R)

So, $R = W$

that is $R = mg$

(alternative A, item 10)

References:

Haber-Schaim, 4th ed., pp. 230-234.
Ingram, Part 1, pp. 71-73.
Mayfield, Book 1, pp. 42-44.
Project Physics, Unit 1, pp. 79-83.
Williams, p. 97.

11 and 12 Correct Responses: 11 B

12 B

Discussion:

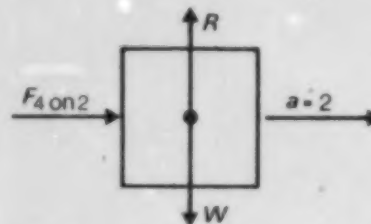
In order to answer these questions it is first necessary to determine the acceleration of the two packing cases moving together under the influence of force F .

Horizontally, net force (N) = mass (kg) $\times$ acceleration (m s^{-2})

$$12 = 6 \times a$$

that is $a = 2 \text{ m s}^{-2}$

Consider forces acting on the 2 kg case



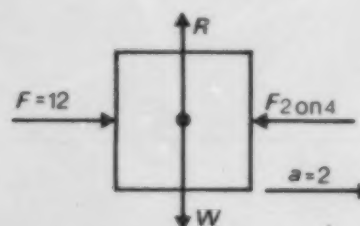
Net force = $m \times a$

$$F_{4 \text{ on } 2} = 2 \times 2$$

$$= 4$$

(alternative B, item 11)

Similarly, for the 4 kg case,



Net force = $m \times a$

that is $F - F_{2 \text{ on } 4} = 4 \times 2$

$$12 - F_{2 \text{ on } 4} = 8$$

$$F_{2 \text{ on } 4} = 4$$

(alternative B, item 12)

References:

Haber-Schaim, 4th ed., p. 235.
Ingram, Part 1, pp. 71, 72.
Mayfield, Book 1, pp. 42-44.
Project Physics, Unit 1, pp. 79-83.
Williams, p. 96.

- 13-16 Correct Responses: 13 D
14 C
15 D
16 B

Discussion:

The gravitational forces on the spanner and feather are different whether on the moon or earth. Statement B is false and statement C while true is not relevant to item 13. The reason why the spanner and feather arrive at the moon's surface together is due to the fact that there is no air resistance on the moon (alternative D).

The ratios for item 14 reduce to g , the gravitational field strength. The ratios will therefore be equal on both the moon and the earth. Of course the values will be different at these two places (alternative C).

The ratio for item 15 reduces to a ratio of masses. This will be the same on the earth as it is on the moon, but naturally greater than one (alternative D).

The inertial mass of an object does not change with location. Thus, a ratio of 1 (alternative B) is the correct response for item 16.

References:

Haber-Schaim, 4th ed., pp. 233, 234.
Ingram, Part 1, pp. 99, 100, 112, 113.
Mayfield, Book 1, pp. 40, 78-81.
Project Physics, Unit 1, p. 83.
Williams, pp. 96-98.

- 17 Correct Response: C

Discussion:

For a given mass, force is proportional to acceleration. The situation initially showed a net force of 200 N producing an acceleration of 5.0 m s^{-2} . When only P is pulling, the net force is double, that is 400 N, and hence the acceleration is doubled to 10 m s^{-2} .

(Alternative C)

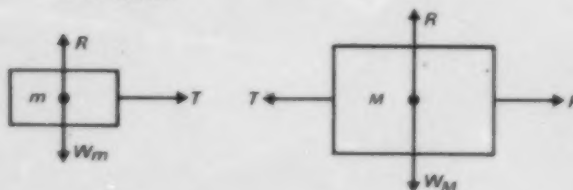
References:

Haber-Schaim, 4th ed., pp. 233, 234.
Ingram, Part 1, p. 72.
Mayfield, Book 1, p. 42.
Project Physics, Unit 1, p. 83.
Williams, pp. 96, 97.

- 18-22 Correct Responses: 18 A
19 B
20 D
21 A
22 A

Discussion:

The diagrams below show the forces acting on the two masses.



As the two masses are joined by a piece of inelastic string, the acceleration of each mass will be the same (alternative B, item 19). Hence, in order to find the acceleration we can consider the masses as a single object of mass $m + M$.

Hence as $F = \text{mass} \times \text{acceleration}$

$$F = (m + M) \times a$$

$$\frac{F}{m + M} = a$$

(Alternative A, item 18).

Resolving forces for the smaller mass, it can be seen that, as force = mass $\times$ acceleration, then

$$T = m \times \frac{F}{m + M}$$

$$= \frac{mF}{m + M} \text{ (Alternative D, item 20).}$$

As there is only one piece of string, the force applied to m by the string must be equal in magnitude to the force it applies to M . The two forces act in opposite directions though, so alternative A is the correct response for item 21.

- 22 The equation of motion for m is $T = ma$

where $a = \frac{F}{m + M}$ (item 18)

therefore $T = \frac{mF}{m + M}$ (Alternative A)

The tension can also be calculated using the larger mass.

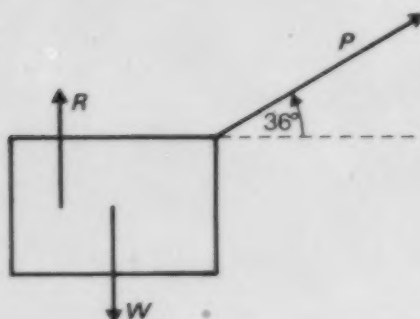
References:

Haber-Schaim, 4th ed., p. 235.
Ingram, Part 1, p. 72.
Mayfield, Book 1, p. 42.
Project Physics, Unit 1, p. 88.
Williams, pp. 96, 97.

- 23-25 Correct Responses: 23 C
24 D
25 C

Discussion:

Consider the diagram showing the forces acting on the trolley.



P = force exerted by boy

W = weight force down

R = upward reaction force of ground on trolley

The horizontal component of the force

$$= P \cos 36^\circ$$

$$= 200 \times 0.8$$

$$= 160 \text{ N}$$

(Alternative C, item 23)

- 24 Weight (N) = mass (kg) $\times$ gravitational field strength (N kg^{-1})
 $= 50 \times 10$
 $= 500 \text{ N}$

(Alternative D)

- 25 Resolving forces in vertical directions

$$R + P \sin 36^\circ = W$$

$$R = W - P \sin 36^\circ$$

$$= 500 - 120$$

$$= 380$$

(Alternative C)

References:

Haber-Schaim, 4th ed., p. 235.
 Ingram, Part 1, pp. 73, 112.
 Mayfield, Book 1, pp. 28, 79.
 Project Physics, Unit 1, p. 79.
 Williams, pp. 49, 50, 98.

- 26 Correct Response: C

Discussion:

Resolving forces in direction of F_3 gives net force

$$= F_3 - (F_1 \cos 60 + F_2 \cos 60)$$

$$= F_3 - (F_1 + F_2) \cos 60$$

$$= 5 - (10 + 10) \frac{1}{2}$$

$$= 5 - 10$$

$$= -5$$

that is, the net force is 5 N in the opposite direction to F_3 .

(Alternative C)

References:

Haber-Schaim, 4th ed., p. 202.
 Ingram, Part 1, p. 225.
 Project Physics, Unit 1, p. 79.
 Williams, p. 53.

- 27-29 Correct Responses: 27 D

28 A

29 B

Discussion:

Figure 1 shows the graph increasing slightly in the sector xy when one would expect no change in velocity. The most likely explanation is that the table is sloping downwards with the force of the cart's weight causing a small acceleration.

(Alternative D, item 27)

- 28 From Figure 2 it can be seen that the force applied has to be greater than zero before an acceleration occurs. However, it is known that if there is no acceleration then there must be no net force acting on the cart. Therefore some opposing force must exist, namely the various frictional forces acting on the cart.

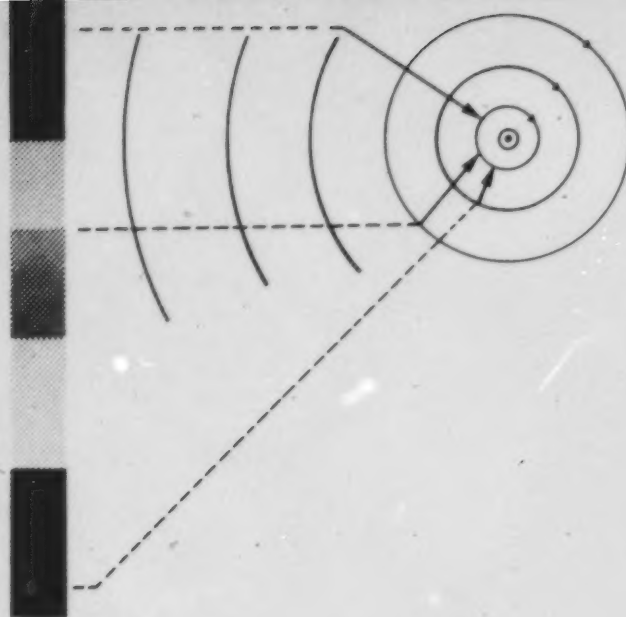
(Alternative A)

- 29 The ratio $\frac{F}{a}$ gives the inertial mass of the cart plus its load of bricks. The reason that the graph does not pass through the origin is due to the fact that the cart itself possesses mass.

(Alternative B)

References:

Haber-Schaim, 4th ed., p. 237.
 Ingram, Part 1, pp. 71, 72.
 Mayfield, Book 1, pp. 37-42.
 Project Physics, Unit 1, p. 79.
 Williams, p. 98.



Diagnostic Aid 6 Work and energy

Description

This diagnostic aid is one of a collection of 21 diagnostic aids corresponding to the 21 separate tests in the *Physics Unit Tests*.

In each diagnostic aid an explanation is provided so that the reasons why the responses are correct or incorrect are available to you.

To gain maximum benefit from the *Physics Unit Tests* weaknesses diagnosed need to be followed up. These diagnostic aids make it possible for you to proceed with this follow up in your own time. If you do not understand the discussion you are advised to seek help from your teacher.

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- Ingram: Ingram, A.D., Kuhl, D.H., McCarthy, i.E., Sandercock, E.R., Smith, W.F., and Waite, P.J. *Physics: A Laboratory-oriented Approach*. (Study Guide Leaving Part 1, Study Guide Matriculation Part 2). Adelaide: Rigby, 1971, 1972.
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1 Correct Response: C**Discussion:**

$$\begin{aligned}
 \text{Loss in kinetic energy} &= \text{initial } E_k - \text{final } E_k \\
 &= \frac{1}{2} m v_i^2 - \frac{1}{2} m v_f^2 \\
 &= \frac{1}{2} m (v_i^2 - v_f^2) \\
 &= \frac{1}{2} \times 800 (20^2 - 15^2) \\
 &= 70\,000 \text{ J} \\
 &= 7 \times 10^4 \text{ J}
 \end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 326.
 Ingram, Part 1, pp. 56, 57.
 Mayfield, Book 1, pp. 62, 63.
 Project Physics, Unit 3, p. 31.
 Williams, Sect. 6.7.

2 Correct Response: A**Discussion:**

$$\begin{aligned}
 \text{Average power generated} &= \frac{\text{work done}}{\text{time taken}} \\
 &= \frac{\text{increase in kinetic energy}}{\text{time taken}} \\
 &= \frac{\text{final } E_k - \text{initial } E_k}{\text{time taken}} \\
 &= \frac{\frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2}{t} \\
 &= \frac{\frac{1}{2} \times 800 \times 15^2 - 0}{5} \\
 &= 18\,000 \text{ W} \\
 &= 1.8 \times 10^4 \text{ W}
 \end{aligned}$$

References:

Haber-Schaim, 4th ed., pp. 352–357.
 Ingram, Part 1, pp. 85–87.
 Mayfield, Book 1, p. 67.
 Project Physics, Unit 3, p. 46.
 Williams, Sect. 6.4.

3 Correct Response: B**Discussion:**

Work done on the trolley

= force on trolley $\times$ displacement of
 trolley $\times$ cosine of the angle between
 force and displacement

$$= F s \cos \theta$$

$$200 = 100 s \cos 60^\circ$$

$$200 = 100 s \cdot 0.5$$

$$200 = 50 s$$

$$4.0 = s$$

that is, distance moved by the trolley during this
 time is 4.0 m.

(Alternative B)

References:

Haber-Schaim, 4th ed., p. 327.
 Ingram, Part 1, pp. 77, 78.
 Mayfield, Book 1, pp. 65, 66.
 Project Physics, Unit 3, p. 39.
 Williams, Sect. 6.1.

4 Correct Response: D**Discussion:**

Kinetic energy lost by the pellet

= work done on the clay by the pellet

= $F s \cos \theta$, where F is the forward force
exerted on the clay by the pellet.

This force is equal in magnitude but opposite in
 direction to the retarding force *exerted on the pellet*
by the clay.

$$\text{So } 5 = F \cdot 1$$

$$\text{giving } F = 50 \text{ N}$$

References:

Haber-Schaim, 4th ed., p. 339.
 Ingram, Part 1, pp. 56, 57, 77, 78.
 Mayfield, Book 1, pp. 65, 66.
 Project Physics, Unit 3, p. 31.

5 Correct Response: A

Discussion:

Since there is no friction, energy changes concern only kinetic energy and gravitational potential energy.

Strictly, **D** is a correct statement, as the overall change in energy equals the *gain* in kinetic energy less the *loss* in potential energy, but it neglects to state that this net change is zero. However, **A** is the best answer, since it indicates that these two changes are *equal*, implying that the total energy is conserved. **C** is incorrect as the *sum* of the *gain* in kinetic energy and *loss* in potential energy would give *twice* the total change in energy. In this frictionless situation, no heat energy would be developed, and so **B** is incorrect.

References:

Haber-Schaim, 4th ed., pp. 352, 361.
Ingram, Part 1, pp. 56, 57.
Mayfield, Book 1, pp. 70, 71.
Project Physics, Unit 3, p. 36.
Williams, Sect. 6.10.

6 Correct Response: D

Discussion:

$$\begin{aligned} \text{Kinetic energy of } M &= \frac{1}{2} m_M v_M^2 \\ \text{Kinetic energy of } N &= \frac{1}{2} m_N v_N^2 \\ &= \frac{v_M^2}{v_N^2}, \quad \text{since } m_M = m_N \\ &= \frac{(2 v_N)^2}{v_N^2}, \quad \text{since } v_M = 2v_N \\ &= 4. \end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 326.
Ingram, Part 1, pp. 56, 57.
Mayfield, Book 1, pp. 62, 63.
Project Physics, Unit 3, p. 31.
Williams, Sect. 6.7.

7 and 8 Correct Responses: 7 D

8 D

Discussion:

7 Loss in kinetic energy of a car

work done on road by tyres while stopping

So the kinetic energy of the car before brakes are applied

- average force exerted on road by tyres
- × distance car travels while stopping
- (in magnitude) average force exerted on tyres by road × distance car travels while stopping

So, for car *M*,

$$E_{KM} = F_M \times S_M$$

and hence the desired ratio is given by

$$\begin{aligned} \frac{E_{KM}}{E_{KN}} &= \frac{F_M}{F_N} \times \frac{S_M}{S_N} \\ \frac{4}{1} &= \frac{F_M}{F_N}, \quad \text{since } S_M = S_N \\ &\quad \text{(Alternative D)} \end{aligned}$$

8 Here it is assumed that the original kinetic energy of each car is converted into heat energy, principally in the brake linings.

Hence,

heat dissipated in brakes of car *M*

heat dissipated in brakes of car *N*

$$\begin{aligned} &= \frac{\text{original kinetic energy of } M}{\text{original kinetic energy of } N} \\ &= \frac{4}{1} \end{aligned}$$

References:

Haber-Schaim, 4th ed., pp. 339, 361.
Ingram, Part 1, pp. 77, 78.
Mayfield, Book 1, pp. 65, 66.
Project Physics, Unit 3, pp. 41, 62.

9 Correct Response: A**Discussion:**

Increase in kinetic energy of the boy
 decrease in his gravitational potential energy

$$\begin{aligned}\text{Thus, } (E_k)_{\text{final}} - (E_k)_{\text{initial}} &= mgh \\ (E_k)_{\text{final}} - 0 &= 40 \times 10 \times 2 \\ (E_k)_{\text{final}} &= 800 \text{ J} \\ &= 8.0 \times 10^2 \text{ J} \\ &\quad (\text{Alternative A})\end{aligned}$$

References:

Haber-Schaim, 4th ed., pp. 352, 361.
 Ingram, Part 1, pp. 56, 57.
 Mayfield, Book 1, pp. 70, 71, 129, 130.
 Project Physics, Unit 3, p. 36.
 Williams, Sect. 6.7.

10 Correct Response: A**Discussion:**

Loss in boy's kinetic energy

- = work done on trampoline
- = average force F exerted on trampoline by boy $\times$ displacement S of point where boy contacts trampoline
- = (in magnitude) average force F exerted on boy by trampoline $\times$ displacement S .

$$800 = F \times 0.20$$

$$\begin{aligned}F &= \frac{800}{0.20} \\ &= 4000 \\ &= 4.0 \times 10^3 \text{ N}\end{aligned}$$

References:

Haber-Schaim, 4th ed., pp. 326, 344.
 Ingram, Part 1, pp. 77, 78.
 Mayfield, Book 1, pp. 65, 66.
 Project Physics, Unit 3, p. 36.

11 Correct Response: B**Discussion:**

If the horizontal level through the unstretched trampoline surface is taken as the zero gravitational potential energy level, the kinetic energy of the boy as he meets (or leaves) the trampoline surface equals the gravitational potential energy (mgh) of the boy at the highest point of his flight.

If his kinetic energy on *leaving* the trampoline = 95% of his kinetic energy on *originally contacting it*,

then his original gravitational potential energy at the top of his flight *after* his first bounce

= 95% of his gravitational potential energy at the top of his flight *before* this first bounce

$$\begin{aligned}mgh_2 &= \frac{95}{100} mgh_1 \\ h_2 &= \frac{95}{100} h_1 = \frac{95}{100} \times 2.0 \text{ m} = 1.9 \text{ m}\end{aligned}$$

References:

Haber-Schaim, 4th ed., pp. 352, 361.
 Ingram, Part 1, pp. 56, 57.
 Mayfield, Book 1, pp. 129, 130.
 Project Physics, Unit 3, p. 36.
 Williams, Sect. 6.6 and 6.7.

12 Correct Response: A**Discussion:**

Work done on wall

- = force applied $\times$ component of displacement in direction of the force
- = $100 \text{ N} \times 0$
- = 0

References:

Haber-Schaim, 4th ed., pp. 326–328.
 Ingram, Part 1, pp. 77, 78.
 Mayfield, Book 1, p. 66.
 Project Physics, Unit 3, p. 39.
 Williams, Sect. 6.1.

13 Correct Response: B**Discussion:**

Since energy is conserved, and there are no heat losses due to friction, kinetic energy of the ball immediately after leaving the spring

= potential energy initially stored in the spring that is,

$$\frac{1}{2} m v^2 = 150$$

$$\frac{1}{2} \times 5 v^2 = 150$$

$$v^2 = 150 \times \frac{2}{5} = 60$$

$$v = \sqrt{60} = 7.7 \text{ m s}^{-1}$$

References:

Haber-Schaim, 4th ed., pp. 344-349.

Ingram, Part 1, pp. 56, 57.

Mayfield, Book 1, pp. 70, 71.

Project Physics, Unit 3, p. 36.

Williams, Sect. 6.9.

**14 and 15 Correct Responses: 14 C
15 D****Discussion:**

- 14** Again, since energy is conserved, and there is no heat loss due to friction, the gravitational potential energy of sphere at top of its flight

= elastic potential energy originally stored in compressed spring

$$mgh = 150$$

$$5 \times 10h = 150$$

$$h = \frac{150}{50}$$

$$= 3.0 \text{ m}$$

- 15** Total energy of the sphere 1.5 m above point of release

= initial total energy of spring and sphere (150 J)

$$\frac{1}{2} m v^2 + mgh = 150$$

$$(\frac{1}{2} \times 5 v^2) + (5 \times 10 \times 1.5) = 150$$

$$\frac{5}{2} v^2 + 75 = 150$$

$$\frac{5}{2} v^2 = 150 - 75$$

$$= 75$$

$$v^2 = 75 \times \frac{2}{5}$$

$$= 30$$

$$v = \sqrt{30}$$

$$= 5.5 \text{ m s}^{-1}$$

References:

Haber-Schaim, 4th ed., pp. 352, 361.

Ingram, Part 1, pp. 56, 57.

Mayfield, Book 1, pp. 70, 71, 129, 130.

Project Physics, Unit 3, p. 36.

Williams, Sect. 6.9, 6.10.

16 Correct Response: A**Discussion:**

If g is the constant gravitational field strength at the surface of the earth, the expression mgh gives the change in gravitational potential energy only if the movement occurs at or near the surface of the earth and h is a vertical displacement.

This is the case only in I. In II, the movement is not near the surface of the earth. In III, h is not a vertical displacement. In IV, neither condition applies; in fact the gravitational potential energy has not changed.

References:

Haber-Schaim, 4th ed., p. 352.

Ingram, Part 1, p. 116.

Mayfield, Book 1, pp. 68, 116.

Williams, Sect. 6.6.

17 Correct Response: C**Discussion:**

If the mass is pulled up at constant speed, the upward force applied by the man will be equal in magnitude and opposite in direction to the weight of the mass, that is 80 N.

So work done = force applied by the man $\times$ displacement in the direction of this force

$$= 80 \times 10$$

$$= 800$$

$$= 8.0 \times 10^2 \text{ J}$$

References:

Ingram, Part 1, pp. 77, 78.

Mayfield, Book 1, pp. 66, 68.

Project Physics, Unit 3, p. 33.

Williams, Sect. 6.1.

18 Correct Response: B**Discussion:**

$$\begin{aligned}
 \text{Average power} &= \frac{\text{work done}}{\text{time taken}} \\
 &= \frac{\text{force} \times \text{displacement}}{\text{time taken}} \\
 &= \text{force} \times \text{velocity} \\
 &= 80 \text{ N} \times 2.0 \text{ m s}^{-1} \\
 &= 1.6 \times 10^2 \text{ W}
 \end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 352.
 Ingram, Part 1, pp. 85–87.
 Mayfield, Book 1, p. 67.
 Project Physics, Unit 3, p. 46.
 Williams, Sect. 6.4.

**19 and 20 Correct Responses: 19 C
20 B****Discussion:**

- 19** Since he applies the same force for the same displacement, he does the same work (as in item 17), that is 800 J.
- 20** However, since he now does this same work in one-third the time, he is now operating at three times the power, that is at $3 \times 160 \text{ W}$, or 480 W.

References:

Ingram, Part 1, pp. 77, 78, 85–87.
 Mayfield, Book 1, pp. 66–68.
 Project Physics, Unit 3, p. 33.
 Williams, Sect. 6.1, 6.4.

21 Correct Response: C**Discussion:**

If the elastic limit of the spring is not exceeded and the spring is loosely wound, that is, adjacent coils are not pressed up against one another, then the extension X is directly proportional to the tension T , resulting in a straight line graph intersecting the origin.

(Alternative C)

References:

Haber-Schaim, 4th ed., p. 344.
 Ingram, Part 1, pp. 81–85.
 Mayfield, Book 1, p. 69.
 Williams, Sect. 7.10.

22 Correct Response: A**Discussion:**

The graph shows that a force comes into play when the separation of the carts is 0.20 m. It steadily increases until the separation is 0.05 m, which is therefore the minimum separation.

**23–25 Correct Responses: 23 C
24 B
25 D****Discussion:**

- 23** Work done = area under force-separation graph
 $= \frac{1}{2} \times 200 \text{ N} (0.20 \text{ m} - 0.05 \text{ m})$
 $= \frac{1}{2} \times 200 \text{ N} \times 0.15 \text{ m}$
 $= 15 \text{ J}$
- 24** This would also be the potential energy stored in the spring at minimum separation, so alternative B is the correct response.
- 25** As the carts approach one another, the larger area under the graph represents the loss in the total kinetic energy of the carts. As the carts move apart, the smaller area under the graph represents the gain in the total kinetic energy as they move apart. Since the force of interaction is less as the carts separate, there will be a net loss in kinetic energy.
 (Alternative D)

References:

Haber-Schaim, 4th ed., pp. 331, 333.

26 Correct Response: D**Discussion:**

To increase the separation, one must apply a force equal to the force of attraction at that separation. Thus, the total work done will be the sum of a series of products, $F_1 \delta x + F_2 \delta x + F_3 \delta x + F_4 \delta x + \dots + F_n \delta x$, where δx represents a very small displacement. The sum of all these products (when δx approaches zero) is the total area under the graph between X_1 and X_2 .

References:

Haber-Schaim, 4th ed., p. 333.
 Williams, Sect. 6.2.

**27 and 28 Correct Responses: 27 B
28 C**

Discussion:

On the surface of the moon the mass will not be changed (alternative B, item 27) but the weight (mg) will be one-sixth of its value on the surface of the earth, since g , the gravitational field strength (and therefore the acceleration due to gravity), is one-sixth of its value at the surface of the earth.

$$\begin{aligned}\text{Thus, Weight} &= mg \\ &= 0.72 \times \frac{10}{6} \\ &= 1.2 \text{ N}\end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 244.
Ingram, Part 1, p. 112.
Mayfield, Book 1, pp. 78-80.
Project Physics, Unit 1, p. 83.
Williams, Sect. 1.7.

29 Correct Response: B

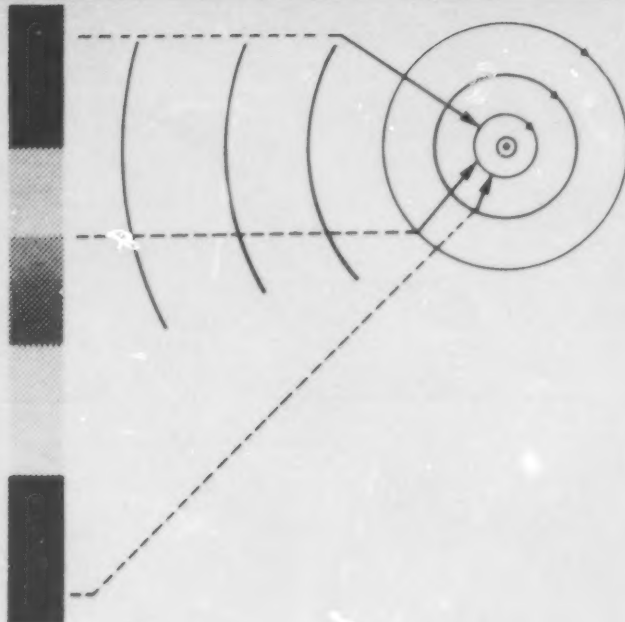
Discussion:

Work done in raising hammer on the moon

$$\begin{aligned}&= \text{increase in gravitational potential energy of hammer} \\ &= mgh \\ &= 0.72 \times \frac{10}{6} \times 2.0 \\ &= 2.4 \text{ J}\end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 352.
Ingram, Part 1, pp. 116, 117.
Mayfield, Book 1, pp. 66, 68.
Project Physics, Unit 3, p. 33.
Williams, Sect. 6.6.



Diagnostic Aid 7 Linear momentum

Description

This diagnostic aid is one of a collection of 21 diagnostic aids corresponding to the 21 separate tests in the *Physics Unit Tests*.

In each diagnostic aid an explanation is provided so that the reasons why the responses are correct or incorrect are available to you.

To gain maximum benefit from the *Physics Unit Tests* weaknesses diagnosed need to be followed up. These diagnostic aids make it possible for you to proceed with this follow up in your own time. If you do not understand the discussion you are advised to seek help from your teacher.

References

The references throughout the Diagnostic Aids have been abbreviated. The abbreviations and full publication details are listed.

- Haber-Schaim: Haber-Schaim, U., Cross, J.B., Dodge, J.H., and Walter, J.A. *PSSC Physics*. 4th ed. Lexington, Mass.: D.C. Heath, 1976. (Reference is also made to 3rd ed.)
- Ingram: Ingram, A.D., Kuhl, D.H., McCarthy, I.E., Sandercock, E.R., Smith, W.F., and Waite, P.J. *Physics: A Laboratory-oriented Approach*. (Study Guide Leaving Part 1, Study Guide Matriculation Part 2). Adelaide: Rigby, 1971, 1972.
- Mayfield: Mayfield, J.M., Parham, R.T., and Webber, B.J. *Fundamentals of Senior Physics*. (Book 1, Book 2). Melbourne: Heinemann Educational Australia Pty Ltd, 1973.
- Project Physics: *Project Physics Course: Programmed Instruction Books* (Kinetic Molecular Theory of Gases, Waves 1-2, Equations 1-3, Vectors 1-3); *Text and Handbook* (Units 1-6). Sydney: Martin Educational, 1970.
- Williams: Williams, J.E., Trinklei, F.E., Metcalfe, H.C., and Lefler, R.W. *Modern Physics*. New York: Holt, Rinehart, & Winston, 1976.

The Australian Council for Educational Research Limited thanks the following publishers for donating textbooks used in referencing the aids: Heinemann Educational Australia Pty Ltd, Richmond, Victoria, for *Fundamentals of Senior Physics*. Rigby Limited, Box Hill, Victoria, for *Physics: A Laboratory-oriented Approach*.

Do not write on this booklet

1 Correct Response: D**Discussion:**

Net force applied = rate of change of momentum produced

$$\begin{aligned}\text{that is, } \vec{F}_{\text{net}} &= \frac{\Delta \vec{p}}{\Delta t} \\ \Delta \vec{p} &= \vec{F}_{\text{net}} \Delta t \\ &= 2 \times 0.4 \\ &= 0.8 \text{ kg m s}^{-1}\end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 304.
Ingram, Part 1, pp. 68-72.
Mayfield, Book 1, p. 59.
Project Physics, Unit 3, p. 16.
Williams, Sect. 4.4.

2 Correct Response: D**Discussion:**

For a given mass, the change in momentum
= mass change in velocity

$$\begin{aligned}\Delta \vec{p} &= m \Delta \vec{v} \\ \text{So } \Delta \vec{v} &= \frac{\Delta \vec{p}}{m} \\ &= \frac{0.8}{4} \\ &= 0.2 \text{ m s}^{-1}\end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 304.
Ingram, Part 1, pp. 68-72.
Mayfield, Book 1, p. 59.
Project Physics, Unit 3, p. 16.
Williams, Sect. 4.4.

3 Correct Response: C**Discussion:**

The loss in momentum of the pellet

$$\begin{aligned}&= \text{its initial momentum} - \text{its final momentum} \\ &= m v_i - m v_f \\ &= (10^{-3} \times 100) - 0 \\ &= 0.1 \text{ kg m s}^{-1}\end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 304.
Ingram, Part 1, pp. 68-72.
Mayfield, Book 1, pp. 59, 60.
Project Physics, Unit 3, p. 16.
Williams, Sect. 4.4.

4 Correct Response: A**Discussion:**

The impulse of the force acting on the pellet
= its change in momentum

$$\text{Thus, } \vec{F}_{\text{net}} \Delta t = \Delta \vec{p}$$

Substituting known values gives

$$\begin{aligned}\vec{F}_{\text{net}} \times 10^{-3} &= 0.1 \\ \vec{F}_{\text{net}} &= \frac{0.1}{10^{-3}} \\ &= 10^2 \text{ N}\end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 304.
Ingram, Part 1, pp. 68-72.
Mayfield, Book 1, pp. 59, 60.
Project Physics, Unit 3, p. 16.
Williams, Sect. 4.4.

5 Correct Response: D**Discussion:**

The change in momentum of the golf ball
= the impulse of the force on the ball

$$= \vec{F} \Delta t$$

As both the force and the time for which it acts are known, no further information is required.

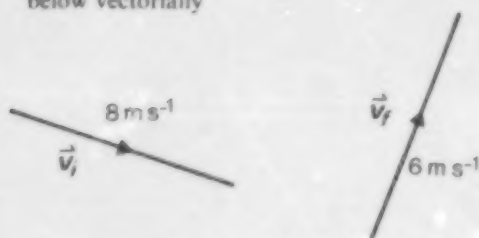
References:

Haber-Schaim, 4th ed., p. 304.
Ingram, Part 1, pp. 68-72.
Mayfield, Book 1, p. 59.
Project Physics, Unit 3, p. 16.
Williams, Sect. 4.4.

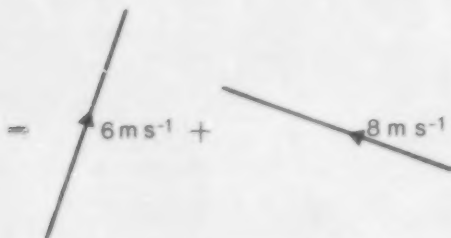
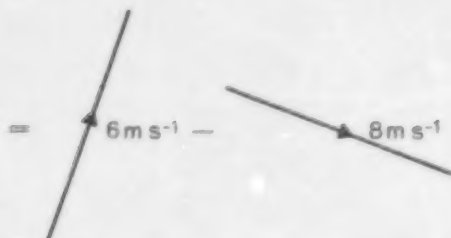
6 Correct Response: B

Discussion:

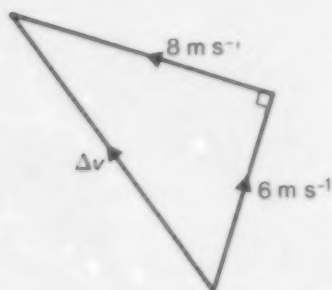
The initial and final velocities of the ball are shown below vectorially



The change in velocity, $\Delta \vec{v} = \vec{v}_f - \vec{v}_i$



The addition of these two vectors is shown below



The resulting triangle is a right-angled triangle, with sides in the well-known 3 : 4 : 5 ratio.

$$\text{So } \Delta \vec{v} = 10 \text{ m s}^{-1}$$

$$\begin{aligned} \text{Change in momentum} &= m \Delta \vec{v} \\ &= 0.5 \times 10 \\ &= 5 \text{ kg m s}^{-1} \end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 304.
Ingram, Part 1, pp. 47-49.
Mayfield, Book 1, pp. 53, 54, 59.
Project Physics, Unit 3, p. 16.
Williams, Sect. 4.5, 4.6.

7 Correct Response: C

Discussion:

If momentum is conserved

$$\text{initial momentum} = \text{final momentum}$$

$$\begin{aligned} \text{So, } m_1 \vec{v}_{1i} + m_2 \vec{v}_{2i} &= m_1 \vec{v}_{1f} + m_2 \vec{v}_{2f} \\ (m_1 \times 4) + 0 &= (m_1 \times \frac{1}{2}) + (m_2 \times 3) \\ 4m_1 &= \frac{1}{2}m_1 + 3m_2 \\ 3\frac{1}{2}m_1 &= 3m_2 \\ \therefore m_1 &< m_2 \end{aligned}$$

References:

Haber-Schaim, 4th ed., pp. 306-313.
Ingram, Part 1, pp. 44-45.
Mayfield, Book 1, pp. 53-56.
Project Physics, Unit 3, pp. 6-19.
Williams, Sect. 4.5.

8 Correct Response: A

Discussion:

The impulse of the force acting on the body

- = the net force acting on the body $\times$ the time for which it acts
- = 5 N south $\times$ 3 s
- = 15 N s south

The impulse does not depend on the original direction of motion of the body.

References:

Haber-Schaim, 4th ed., pp. 302-304.
Ingram, Part 1, p. 72.
Mayfield, Book 1, p. 59.
Williams, Sect. 4.4.

9 Correct Response: D

Discussion:

Since the boy and ground will both exert forces on each other, they both exert impulses on each other. A and B are therefore correct.

C is correct. Since momentum is conserved, the momentum of the boy before striking the ground will equal the combined momenta of the boy and ground after landing on the ground.

D is incorrect, since momentum is not transformed into energy. Only energy can be transformed into energy.

References:

Haber-Schaim, 4th ed., pp. 306–313.

Ingram, Part 1, pp. 44–49, 72.

Mayfield, Book 1, pp. 53–56.

Project Physics, Unit 3, pp. 6–19.

Williams, Sect. 4.5.

10 Correct Response: D

Discussion:

The total momentum of the girl and skateboard will remain constant while she leaves the skateboard. So if her forward momentum is less after she leaves the board, then the forward momentum of the board must increase by an amount equal to her loss in momentum,

$$\begin{aligned}\text{that is, } \Delta \vec{p}_{\text{board}} &= -\Delta \vec{p}_{\text{girl}} \\ m_{\text{board}} \Delta \vec{v}_{\text{board}} &= -m_{\text{girl}} \Delta \vec{v}_{\text{girl}}\end{aligned}$$

So the forward velocity of the board will increase, but this increase cannot be related to the decrease in the girl's forward velocity *without knowing the two masses*.

References:

Haber-Schaim, 4th ed., pp. 306–313.

Ingram, Part 1, pp. 44–49.

Mayfield, Book 1, pp. 53–56.

Project Physics, Unit 3, pp. 6–19.

Williams, Sect. 4.3.

11 Correct Response: B

Discussion:

The impulse of the body over the first 5 s

the change in momentum of the body during that time

20 kg m s^{-1} (from graph)

References:

Haber-Schaim, 4th ed., pp. 304–306.

Ingram, Part 1, p. 72.

Mayfield, Book 1, p. 59.

Williams, Sect. 4.4.

12–14 Correct Responses: 12 A

13 A

14 B

Discussion:

The resultant or net force acting on the body

the rate of change of momentum of the body

$\frac{\Delta \vec{p}}{\Delta t}$ (that is, the gradient of the graph)

(alternative A, item 13)

$\frac{20 \text{ kg m s}^{-1}}{5 \text{ s}}$

$= 4 \text{ N}$

(alternative A, item 12)

14 Since the graph has a non-zero gradient from 0–5 s and from 10–15 s, it has a non-zero net force and therefore an acceleration. In the other two intervals, the gradient (and therefore the net force) is zero, so the acceleration is zero and the object moves at constant velocity.

(alternative B)

References:

Haber-Schaim, 4th ed., pp. 304–306.

Ingram, Part 1, pp. 68–72.

Mayfield, Book 1, p. 59.

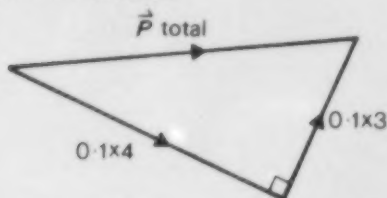
Project Physics, Unit 3, pp. 16–18.

Williams, Sect. 4.4.

**15 and 16 Correct Responses: 15 D
16 B**

Discussion:

The total momentum of the system before the interaction = the total momentum after the interaction, which is given below by adding the two momenta after the collision.



$P_{\text{total}} = 0.1 \times 5$, since we have a 3-4-5 right-angle triangle
 $= 0.5 \text{ kg m s}^{-1}$ (alternative D, item 15)

But $P_{\text{total}} = mu_1$
 So $0.5 = 0.1u_1$
 $u_1 = 5 \text{ m s}^{-1}$ (alternative B, item 16)

Alternatively, since the collision is elastic, kinetic energy is conserved.

so kinetic energy before the collision = kinetic energy after the collision

$$\begin{aligned} \frac{1}{2} \times 0.1 \times u_1^2 &= \left(\frac{1}{2} \times 0.1 \times 3^2 \right) \\ &\quad + \left(\frac{1}{2} \times 0.1 \times 4^2 \right) \\ u_1^2 &= 3^2 + 4^2 \\ &= 9 + 16 \\ &= 25 \end{aligned}$$

So $u_1 = 5 \text{ m s}^{-1}$

References:

Haber-Schaim, 4th ed., pp. 306-313, 333-335.
 Ingram, Part 1, pp. 44-49, 59, 60.
 Mayfield, Book 1, pp. 53-56, 62-64.
 Project Physics, Unit 3, p. 24.
 Williams, Sect. 4.6.

17 Correct Response: C

Discussion:

Since momentum is conserved,
 total momentum before the collision = total momentum after the collision.

This gives

$$(1.5 \times 5) + 0 = (1.5 \times -3) + (4 \times v_{2f})$$

where v_{2f} is the final velocity of the second cart.

$$\text{Hence, } 7.5 = -4.5 + 4v_{2f}$$

$$4v_{2f} = 12$$

$$v_{2f} = 3 \text{ m s}^{-1} \quad (\text{alternative C})$$

References:

Haber-Schaim, 4th ed., pp. 306-313.
 Ingram, Part 1, pp. 44-49.
 Mayfield, Book 1, pp. 53-56.
 Project Physics, Unit 3, pp. 6-19.
 Williams, Sect. 4.6.

18 Correct Response: A

Discussion:

Impulse of the average force acting on, say, the cart that was initially at rest

= the increase in momentum produced in that cart

$$\begin{aligned} \vec{F}_{av} \Delta t &= m \Delta \vec{v} \\ \vec{F}_{av} &= 0.01 \frac{4 \times (3 - 0)}{0.01} \\ &= 1200 \text{ N} \end{aligned}$$

References:

Haber-Schaim, 4th ed., pp. 304-306, 318, 319.
 Ingram, Part 1, pp. 68-72.
 Mayfield, Book 1, p. 59.
 Project Physics, Unit 3, pp. 16-18.
 Williams, Sect. 4.6.

19-21 Correct Responses: 19 B

20 B

21 B

Discussion:

19 The impulse, which is the product of the force and the time for which it is acting, equals the area under the force-time graph and also equals the change in momentum of the body.

Impulse for the first 2 s = area under graph for the first 2 s

$$\begin{aligned} &= F_{av} \times t \\ &= 3 \times 2 \\ &= 6 \text{ kg m s}^{-1} \end{aligned}$$

20 Total impulse = total area under graph

$$\begin{aligned} &= (3 \times 2) + (6 \times 1) + (3 \times 1) \\ &= 6 + 6 + 3 \\ &= 15 \text{ kg m s}^{-1} \end{aligned}$$

21 Now the total impulse = the change in momentum of the body

$$15 \text{ kg m s}^{-1} \text{ to the west} = m \Delta \vec{v}$$

$$\Delta \vec{v} = \frac{15}{m}$$

$$= \frac{15}{2}$$

$$= 7.5 \text{ m s}^{-1} \text{ to the west}$$

$$\vec{v}_f = \vec{v}_i + \Delta \vec{v}$$

$$= 1.5 + 7.5$$

$$= 9.0 \text{ m s}^{-1} \text{ to the west}$$

References:

Haber-Schaim, 4th ed., pp. 302-304.
 Ingram, Part 1, p. 72.
 Mayfield, Book 1, p. 59.
 Project Physics, Unit 3, pp. 16-18.
 Williams, Sect. 4.4, 4.5.

22 Correct Response: C

Discussion:

If the force acts in the *opposite* direction, then the impulse during the first 2 s and the total impulse will be reversed in direction but unchanged in magnitude. However, the change in velocity will now be 7.5 m s^{-1} *to the east*, making the final velocity 1.5 m s^{-1} west plus 7.5 m s^{-1} east, or 6.0 m s^{-1} east, which does not have the same magnitude as the previous final velocity. So **C** is correct.

References:

Haber-Schaim, 4th ed., pp. 302–306.

Williams, Sect. 4.4, 4.5.

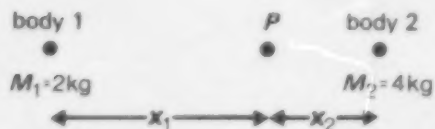
23–25 Correct Responses: 23 C

24 B

25 C

Discussion:

- 23** The centre of mass of the two bodies divides the line joining them in the inverse ratio of their masses.



So if *P* is the centre of mass

$$\frac{x_1}{x_2} = \frac{m_2}{m_1}$$

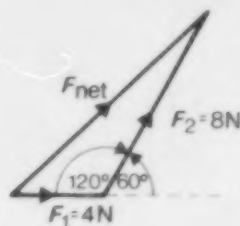
$$= \frac{4}{2}$$

$$= 2$$

Thus point III is the centre of mass.

(alternative C)

- 24** Apparent net force $\vec{F}_{\text{net}}$ on the system equals the sum of the two forces $\vec{F}_1$ and $\vec{F}_2$ acting on the system.



Using the cosine rule in the vector addition diagram.

$$F_{\text{net}}^2 = F_1^2 + F_2^2 - 2F_1F_2 \cos 120$$

$$= F_1^2 + F_2^2 - 2F_1F_2 (-\cos 60)$$

$$= 4^2 + 8^2 - 2 \times 4 \times 8 \left(-\frac{1}{2}\right)$$

$$= 16 + 64 + 32$$

$$= 112$$

$$F_{\text{net}} = \sqrt{112}$$

$$= 4\sqrt{7}$$

So $F_{\text{net}} = 4\sqrt{7} \text{ N}$

- 25** Acceleration of centre of mass

$$\frac{\text{Net force on centre of mass}}{\text{total mass of system}}$$

$$= \frac{4\sqrt{7}}{6}$$

$$= \frac{2}{3}\sqrt{7} \text{ m s}^{-2}$$

References:

Haber-Schaim, 4th ed., pp. 314–318.

Ingram, Part 1, pp. 49–51.

26 Correct Response: C

Discussion:

If the momentum of the system is conserved the velocity of the centre of mass is the same before and after the interaction. I and II are therefore incorrect. For the response IV to have been correct the balls would have had to be at least approaching one another in a straight line. Thus, III (alternative C) is the correct answer.

References:

Haber-Schaim, 4th ed., pp. 314–318.

Ingram, Part 1, pp. 49–51.

27 and 28 Correct Responses: 27 A
28 D

Discussion

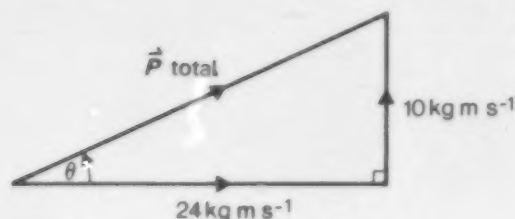
27 Total momentum = $m_1 \vec{v}_1 + m_2 \vec{v}_2 + m_3 \vec{v}_3$

$$\begin{aligned} & (4 \text{ kg} \times 7 \text{ m s}^{-1} \text{ east}) \\ & + (2 \text{ kg} \times 5 \text{ m s}^{-1} \text{ north}) \\ & + (1 \text{ kg} \times 4 \text{ m s}^{-1} \text{ west}) \\ & 28 \text{ kg m s}^{-1} \text{ east} + 10 \text{ kg m s}^{-1} \text{ north} \\ & - 4 \text{ kg m s}^{-1} \text{ west} \\ & 24 \text{ kg m s}^{-1} \text{ east} + 10 \text{ kg m s}^{-1} \text{ north} \end{aligned}$$

$$\begin{aligned} P_{\text{total}} &= \sqrt{24^2 + 10^2} \\ &= \sqrt{576 + 100} \\ &= \sqrt{676} \\ &= 26 \text{ kg m s}^{-1} \end{aligned}$$

28 If θ is the direction (north of east) of $\vec{P}_{\text{total}}$, then

$$\tan \theta = \frac{10}{24} = \frac{5}{12}$$



References:

Haber-Schaim, 4th ed., pp. 311–313.
Mayfield, Book 1, pp. 53, 54, 56.
Williams, Sect. 4.4, 4.5.

29 and 30 Correct Responses: 29 B
30 A

Discussion:

Total momentum of the system before the explosion was zero, so the total momentum after the explosion equals zero.

that is, $m \vec{v}_I + m \vec{v}_{II} + m \vec{v}_{III} = 0$. . . (i)

Now $\frac{\vec{v}}{t} = \frac{\vec{S}}{t}$

so if $\vec{S}_I$, $\vec{S}_{II}$ and $\vec{S}_{III}$ represent the displacements of the three fragments in the 0.1 s after the explosion, equation (i) becomes

$$m \frac{\vec{S}_I}{0.1} + m \frac{\vec{S}_{II}}{0.1} + m \frac{\vec{S}_{III}}{0.1} = 0$$

So $\vec{S}_I + \vec{S}_{II} + \vec{S}_{III} = 0$

It follows that both the x-components of these three vectors and their y-components must be equal to zero.

So x-component of $\vec{S}_I$ + x-component of $\vec{S}_{II}$
+ x-component of $\vec{S}_{III}$
= 0

$(-6) + (+6) + \text{x-component of } \vec{S}_{III}$
= 0

x-component of $\vec{S}_{III} = 0$

(alternative B, item 29)

Also y-component of $\vec{S}_I$ + y-component of $\vec{S}_{II}$
+ y-component of $\vec{S}_{III}$
= 0

$(-3) + (+7) + \text{y-component of } \vec{S}_{III} = 0$

$4 + \text{y-component of } \vec{S}_{III} = 0$

$\therefore \text{y-component of } \vec{S}_{III} = -4$

(alternative A, item 30)

References:

Haber-Schaim, 4th ed., pp. 306–313.
Ingram, Part 1, pp. 44–49.
Mayfield, Book 1, pp. 56, 57.
Project Physics, Unit 3, pp. 8–19.
Williams, Sect. 4.5.

ACER PHYSICS UNIT TESTS

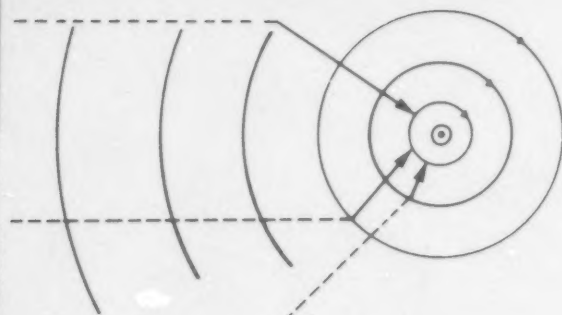
The ACER Physics Unit Tests consist of the following publications.

I A collection of tests covering the following topics

- 1 *Physical measurement*
- 2 *Vectors*
- 3 *Motion in one dimension*
- 4 *Motion on a plane*
- 5 *Dynamics*
- 6 *Work and energy*
- 7 *Linear momentum*
- 8 *Oscillations*
- 9 *Gravity and Kepler's laws*
- 10 *Waves*
- 11 *Light — reflection and refraction*
- 12 *Light — interference, diffraction and spectra*
- 13 *Models of light*
- 14 *Kinetic theory of gases*
- 15 *Static charges*
- 16 *Electric field and potential difference*
- 17 *Current electricity*
- 18 *The magnetic field*
- 19 *Induced EMF*
- 20 *Atomic physics*
- 21 *Quantum physics*

II A collection of 21 Diagnostic Aids covering topics corresponding to the tests.

III Teachers Handbook



Diagnostic Aid 8 Oscillations

Description

This diagnostic aid is one of a collection of 21 diagnostic aids corresponding to the 21 separate tests in the *Physics Unit Tests*.

In each diagnostic aid an explanation is provided so that the reasons why the responses are correct or incorrect are available to you.

To gain maximum benefit from the *Physics Unit Tests* weaknesses diagnosed need to be followed up. These diagnostic aids make it possible for you to proceed with this follow up in your own time. If you do not understand the discussion you are advised to seek help from your teacher.

References

The references throughout the Diagnostic Aids have been abbreviated. The abbreviations and full publication details are listed.

- Haber-Schaim: Haber-Schaim, U., Cross, J.B., Dodge, J.H., and Walter, J.A. *PSSC Physics*. 4th ed. Lexington, Mass.: D.C. Heath, 1976. (Reference is also made to 3rd ed.)
- Ingram: Ingram, A.D., Kuhl, D.H., McCarthy, I.E., Sandercock, E.R., Smith, W.F., and Waite, P.J. *Physics: A Laboratory-oriented Approach*. (Study Guide Leaving Part 1, Study Guide Matriculation Part 2). Adelaide: Rigby, 1971, 1972.
- Mayfield: Mayfield, J.M. Parham, R.T., and Webber, B.J. *Fundamentals of Senior Physics*. (Book 1, Book 2). Melbourne: Heinemann Educational Australia Pty Ltd, 1973.
- Project Physics: *Project Physics Course: Programmed Instruction Books* (Kinetic Molecular Theory of Gases, Waves 1-2, Equations 1-3, Vectors 1-3); *Text and Handbook* (Units 1-6). Sydney: Martin Educational, 1970.
- Williams: Williams, J.E., Trinklei, F.E., Metcalfe, H.C., and Lefler, R.W. *Modern Physics*. New York: Holt, Rinehart, & Winston, 1976.

The Australian Council for Educational Research Limited thanks the following publishers for donating textbooks used in referencing the aids: Heinemann Educational Australia Pty Ltd, Richmond, Victoria, for *Fundamentals of Senior Physics*. Rigby Limited, Box Hill, Victoria, for *Physics: A Laboratory-oriented Approach*.

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1 Correct Response: B**Discussion:**

The period of a simple pendulum is given by the formula $T = 2\pi\sqrt{\frac{l}{g}}$, where l = length of pendulum and g = acceleration due to gravity. Hence, the period is independent of the mass of the bob. Alternative **B** gives the new period. Alternative **D** could be obtained by the use of the formula for the period of a mass attached to a helical spring, which is not applicable to this question.

References:

Haber-Schaim, 4th ed., p. 262.
Ingram, Part 2, p. 227.
Mayfield, Book 2, p. 66.
Williams, p. 128.

2 Correct Response: D**Discussion:**

The period of a light helical spring is given by the formula, $T = 2\pi\sqrt{\frac{m}{k}}$, where m = mass of the bob and k = spring constant. T is proportional to $\sqrt{m}$. The mass is increased by a factor of 4, so the period is doubled. Alternative **B** could reflect the use of the pendulum formula from the last question.

References:

Haber-Schaim, 4th ed., p. 260.
Ingram, Part 2, p. 226.
Mayfield, Book 2, p. 63.
Williams, p. 126.

3 Correct Response: C**Discussion:**

In SHM, the acceleration of the particle by definition is proportional to its displacement and acts towards the centre of the motion, that is, $a = -kx$. The velocity is zero at the extremities of the motion and a maximum at the centre. Hence, maximum velocity occurs with zero displacement which is also where the acceleration is zero (alternative C). The alternatives **A**, **B** and **D**, and maximum acceleration, all occur at the same time and place.

References:

Haber-Schaim, 4th ed., p. 258.
Ingram, Part 2, pp. 221-223.
Mayfield, Book 2, pp. 58, 67.
Williams, p. 127.

4 Correct Response: C**Discussion:**

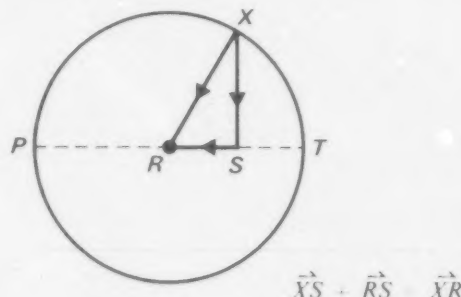
The extreme points, P and T , will be on a diameter of the circle made by the rotating mass. Hence $PT = 2 \times 0.15 = 0.30$ m.

References:

Haber-Schaim, 4th ed., p. 259.
Ingram, Part 2, pp. 221-223.
Mayfield, Book 2, pp. 60, 61.
Williams, p. 127.

5 Correct Response: C**Discussion:**

This is a common way of demonstrating SHM. To prove it, the centripetal acceleration experienced by the mass can be broken up into two components—parallel and perpendicular to the diameter PT .



The component of the acceleration along PT is proportional to RS and directed toward R .

References:

Haber-Schaim, 4th ed., pp. 258, 259.
Ingram, Part 2, pp. 221, 222.
Mayfield, Book 2, pp. 56-59.
Williams, p. 127.

6 Correct Response: A**Discussion:**

In SHM, the speed of the mass is greatest at the centre of the motion. Alternative **D** would be correct if the observer were above the table.

References:

Haber-Schaim, 4th ed., pp. 258, 348.
Ingram, Part 2, p. 223.
Mayfield, Book 2, p. 57.
Williams, Sect. 5.13.

7 Correct Response: A

Discussion:

In SHM, the acceleration is greatest where the displacement is greatest, that is, at the extremities P , T .

References:

Haber-Schaim, 4th ed., p. 258.
Ingram, Part 2, pp. 221–223.
Mayfield, Book 2, p. 58.
Williams, p. 127.

8 Correct Response: A

Discussion:

The period of the pendulum is given by the formula

$T = 2\pi\sqrt{\frac{l}{g}}$, where l = length of the pendulum and

g = acceleration due to gravity. Hence $T \propto \frac{1}{\sqrt{g}}$ and so, if $g_{\text{moon}} < g_{\text{earth}}$, then $T_{\text{moon}} > T_{\text{earth}}$. (Alternative A).

Alternative D is incorrect as the restoring force is provided by the force of gravity.

References:

Haber-Schaim, 4th ed., p. 262.
Ingram, Part 2, p. 227.
Mayfield, Book 2, p. 66.
Williams, p. 127.

9 Correct Response: C

Discussion:

To obtain resonance, the push and pull of the driving force has to be in synchronization with the to and fro motion of the free particle, that is, the frequencies must be the same.

References:

Ingram, Part 2, p. 228.
Mayfield, Book 2, p. 82.

10 Correct Response: D

Discussion:

Force constant	applied force deflection
	0.4 N
	0.04 m
	40
	4
	10 N m ⁻¹

References:

Haber-Schaim, 4th ed., pp. 344–347.
Ingram, Part 2, p. 225.
Mayfield, Book 1, p. 69; Book 2, p. 63.
Williams, Sect. 7.10, p. 157.

11 Correct Response: B

Discussion:

The period is given by the formula $T = 2\pi\sqrt{\frac{m}{k}}$ where m = mass and k = spring constant.

Hence,

$$T = 2\pi\sqrt{\frac{2.5}{10}}$$
$$= 2\pi\sqrt{\frac{1}{4}}$$
$$= \frac{2\pi}{2}$$
$$= \pi \text{ sec.}$$

References:

Haber-Schaim, 4th ed., p. 260.
Ingram, Part 2, p. 226.
Mayfield, Book 2, p. 63.

12 Correct Response: A

Discussion:

The formula for stored potential energy in a spring is given by $\frac{1}{2}kx^2$ where x is the displacement from the centre (rest) position. Therefore potential energy at $x = 0.05$ m is equal to

$$\frac{1}{2} \times 10 \times (0.05)^2 = 5 \times 25 \times 10^{-4}$$
$$= 1.25 \times 10^{-2} \text{ J}$$

References:

Haber-Schaim, 4th ed., p. 347.
Ingram, Part 2, p. 225.
Mayfield, Book 1, p. 69.
Williams, pp. 157, 158.

13 Correct Response: C**Discussion:**

The speed of the blade tip at the centre can be calculated in two ways:

(i) By conservation of energy—the stored potential energy at maximum deflection equals the kinetic energy at the equilibrium position.

$$\begin{aligned}\text{Hence, } \frac{1}{2}kx^2 &= \frac{1}{2}mv^2 \Rightarrow v^2 = \frac{kx^2}{m} \\ \Rightarrow v &= x\sqrt{\frac{k}{m}} \\ &= 0.05\sqrt{\frac{10}{2.5}} \\ v &= 0.05\sqrt{4} \\ &= 0.05 \times 2 \\ &= 0.10 \text{ m s}^{-1}\end{aligned}$$

(ii) The velocity at the equilibrium position is the velocity of a mass moving on the equivalent circular motion (see item 4).

$$\begin{aligned}v &= \frac{2\pi x}{T} \\ &= \frac{2\pi \times 0.05}{\pi} \\ &= 0.10 \text{ m s}^{-1}\end{aligned}$$

References:

Haber-Schaim, 4th ed., pp. 259, 348.
Ingram, Part 2, pp. 224, 225.
Mayfield, Book 2, p. 67.

14 Correct Response: A**Discussion:**

For the blade,

applied force = spring constant $\times$ deflection.

The applied force is the weight of the 0.025 kg mass.

$$\begin{aligned}\text{Hence, the deflection} &= \frac{0.025 \times 10}{k} \\ &= \frac{0.25}{10} \\ &= 0.025 \text{ m}\end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 346.
Ingram, Part 2, p. 225.
Mayfield, Book 1, p. 69.

15 Correct Response: B**Discussion:**

Using the period formula from item 11,

$$\begin{aligned}T &= 2\pi\sqrt{\frac{m}{k}} \\ \text{the period} &= 2\pi\sqrt{\frac{0.025}{10}} \\ &= 2\pi \times 0.05 \\ &= \frac{\pi}{10}\end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 260.
Ingram, Part 2, p. 226.
Mayfield, Book 2, p. 63.

16 Correct Response: B**Discussion:**

Velocity is the time rate of change of displacement. Hence the velocity-time graph can be obtained from the gradient of the displacement-time graph (alternative B).

References:

Haber-Schaim, 4th ed., p. 189.
Ingram, Part 2, p. 223.
Mayfield, Book 2, pp. 57, 67.

17 Correct Response: D**Discussion:**

Acceleration is the time rate of change of velocity. So the acceleration-time graph can be obtained from the gradient of the velocity-time graph. Hence D is the correct response.

The correct graph could also be obtained by using

the equation: acceleration = $-\frac{k}{m} \times x$, where x = displacement. This equation states that the magnitude of the acceleration moves in step with the displacement, but the direction is reversed.

Because of the method used in the first part of the answer, consequential answers exist: 16 A leads to 17 B, 16 C leads to 17 A and 16 D leads to 17 C.

References:

Haber-Schaim, 4th ed., p. 185.
Ingram, Part 2, p. 223.
Mayfield, Book 2, pp. 57, 67.

18 Correct Response: D**Discussion:**

The restoring force per unit displacement is the constant, k , in the formula $F = -kx$. In order to calculate k from the period T , the formula

$T = 2\pi\sqrt{\frac{m}{k}}$ has to be rearranged.

$$\begin{aligned}\frac{T}{2\pi} &= \sqrt{\frac{m}{k}} \\ \frac{T^2}{4\pi^2} &= \frac{m}{k} \\ k &= \frac{4\pi^2 m}{T^2} \\ \text{hence } k &= \frac{4 \times 4\pi^2 \times 2}{\pi^2} \\ &= 8 \text{ N m}^{-1}\end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 260.
Ingram, Part 2, p. 226.
Mayfield, Book 2, p. 63.
Williams, p. 157.

19 Correct Response: A**Discussion:**

S is the extremity of the motion, therefore the velocity is zero.

References:

Haber-Schaim, 4th ed., pp. 259, 348.
Ingram, Part 2, p. 223.
Mayfield, Book 2, p. 57.
Williams, p. 157.

20 Correct Response: B**Discussion:**

Because R is the centre of the motion, the velocity of the cart is the same as the velocity of a particle moving in the equivalent circle. A formula for this velocity is:

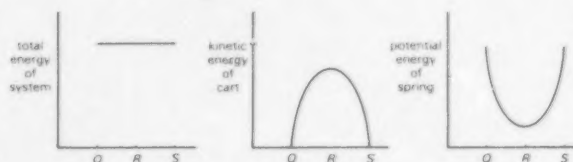
$$\begin{aligned}v &= \frac{2\pi R}{T} \\ &= \frac{2\pi \cdot 0.1}{\pi} \\ &= 0.2 \text{ sec.}\end{aligned}$$

References:

Haber-Schaim, 4th ed., pp. 259, 348.
Ingram, Part 2, pp. 221–223.
Mayfield, Book 2, p. 59.
Williams, p. 157.

21 and 22 Correct Responses: 21 A**22 B****Discussion:**

The system in items 18 to 22 is the cart and the springs. The total energy in this system is constant and is made up of two parts: kinetic energy of the cart and potential energy in the springs. During the oscillation, the variation of these two parts is out of phase.



At S, the kinetic energy of the cart is zero.

(Alternative A, item 21)

At R, the kinetic energy is a maximum and can be calculated using the answer from item 20.

$$\begin{aligned}&= \frac{1}{2}mv^2 \\ &= \frac{1}{2} \times 2 \times (0.2)^2 \\ &= 0.04 \text{ J}\end{aligned}$$

(Alternative B, item 22)

References:

Haber-Schaim, 4th ed., p. 348.
Ingram, Part 2, pp. 224–225.
Mayfield, Book 2, p. 67.
Williams, pp. 157, 158.

23 Correct Response: D**Discussion:**

The velocity–time graph is obtained by getting the gradient of the displacement–time graph. The acceleration–time graph can be quickly obtained from the displacement–time graph by reflecting the graph about the time-axis. (There is also a scale change which does not matter here.) Graphs I, III and IV satisfy the relevant criteria.

References:

Haber-Schaim, 4th ed., p. 258.
Ingram, Part 2, p. 223.
Mayfield, Book 2, pp. 57, 67.

24 Correct Response: D**Discussion:**

At $t = 0$, the displacement is positive, hence D is the only alternative.

References:

Williams, Sect. 7.9, p. 156.

25 Correct Response: F**Discussion:**

The net force is proportional to the acceleration and in the same direction. Following the discussion in item 23, the force-time graph must be the reflection of the displacement-time graph, giving graph F as the correct response. A number of consequential responses from item 24 exist, viz $A \rightarrow B$, $B \rightarrow A$, $C \rightarrow E$, $E \rightarrow C$. An answer of A or B would suggest that the student was confusing the force-time graph with the force-displacement relationship.

References:

Haber-Schaim, 4th ed., p. 258.
Ingram, Part 2, p. 223.
Mayfield, Book 2, p. 62.
Williams, Sect. 7.9, p. 156.

26 Correct Response: B**Discussion:**

The force-displacement relationship can be determined by the equation $\vec{F} = -k\vec{x}$, that is, the equation is of the form $y = mx + c$, which is a straight line with a y -intercept of zero and a negative gradient.

(Alternative B)

References:

Haber-Schaim, 4th ed., pp. 258, 347.
Ingram, Part 2, p. 225.
Mayfield, Book 1, p. 69.
Williams, Sect. 7.9, p. 156.

27 Correct Response: C**Discussion:**

The period of simple harmonic motion is independent of the amplitude, hence the period of this oscillation is still T.

(Alternative C)

References:

Haber-Schaim, 4th ed., p. 260.
Ingram, Part 2, pp. 226, 227.
Mayfield, Book 2, p. 63.

28 Correct Response: E**Discussion:**

The total energy of the system can be given by the formula $\frac{1}{2} k (\text{amplitude})^2$

Total energy for W - Z motion $\propto (OW)^2$

Total energy for X - Y motion $\propto (OX)^2$

But $(OW) = 2 \times (OX)$

Hence, the ratio of the energies $= \frac{[2 \times (OX)]^2}{(OX)^2}$
 $= 4$

References:

Haber-Schaim, 4th ed., p. 347.
Ingram, Part 2, pp. 224, 225.
Mayfield, Book 1, p. 69; Book 2, p. 66.

29 Correct Response: C**Discussion:**

The total energy of a system undergoing SHM appears in two forms—kinetic energy of the mass and the potential energy stored in the spring or in the gravitational field in the case of a pendulum.

$$E_0 = U_1 + Ek$$

$$E_0 = U_1 + \frac{1}{2} mv^2$$

Rearranging $E_0 - U_1 = \frac{1}{2} mv^2$

$$\frac{2(E_0 - U_1)}{m} = v^2$$

$$\therefore v = \sqrt{\frac{2(E_0 - U_1)}{m}}$$

References:

Haber-Schaim, 4th ed., pp. 348-350.
Ingram, Part 2, pp. 224, 225.
Mayfield, Book 2, pp. 66, 67.

30 Correct Response: D**Discussion:**

During the damping of SHM, the period is constant as is observed with the decay of a musical note. Another aspect of damping is implicit in the use of the word "decay"—the amplitude decreases exponentially. Now,

A has a decreasing period and an exponential decay.

B has a decreasing period and a linear decay.

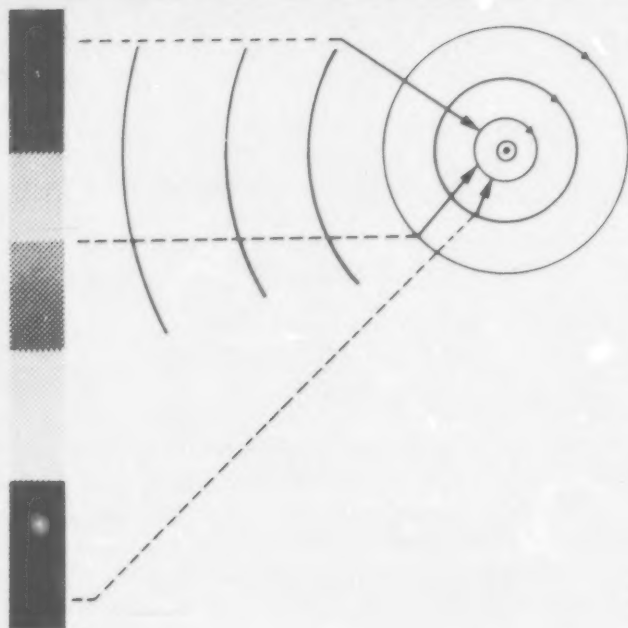
C has a constant period but does not decay, and

D has a constant period and an exponential decay.

Hence, D is the only correct alternative.

References:

Ingram, Part 2, p. 228.



Diagnostic Aid 9 Gravity and Kepler's laws

Description

This diagnostic aid is one of a collection of 21 diagnostic aids corresponding to the 21 separate tests in the *Physics Unit Tests*.

In each diagnostic aid an explanation is provided so that the reasons why the responses are correct or incorrect are available to you.

To gain maximum benefit from the *Physics Unit Tests* weaknesses diagnosed need to be followed up. These diagnostic aids make it possible for you to proceed with this follow up in your own time. If you do not understand the discussion you are advised to seek help from your teacher.

References

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- Mayfield: Mayfield, J.M. Parham, R.T., and Webber, B.J. *Fundamentals of Senior Physics*. (Book 1, Book 2). Melbourne: Heinemann Educational Australia Pty Ltd, 1973.
- Project Physics: *Project Physics Course: Programmed Instruction Books* (Kinetic Molecular Theory of Gases, Waves 1-2, Equations 1-3, Vectors 1-3); *Text and Handbook* (Units 1-6). Sydney: Martin Educational, 1970.
- Williams: Williams, J.E., Trinklei, F.E., Metcalfe, H.C., and Lefler, R.W. *Modern Physics*. New York: Holt, Rinehart, & Winston, 1976.

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Gravity and Kepler's Laws

1 Correct Response: D

Discussion:

Newton's law of gravitation states that the force exerted by a mass, m_1 , on another mass, m_2 , is given by the formula $F = \frac{Gm_1m_2}{r^2}$, where G is the universal constant of gravitation, and r is the distance between the centres of mass of the two masses. Consequently, the force is proportional to the product of the masses (m_1m_2) and inversely proportional to the square of the separation of their centres of mass.

In alternative C, the two components have been reversed.

References:

Haber-Schaim, 4th ed., p. 292.
Ingram, Part 1, p. 108.
Mayfield, Book 1, p. 82.
Project Physics, Unit 2, p. 100.
Williams, p. 104.

2 Correct Response: A

Discussion:

Rearranging Newton's law of gravitation gives

$$G = \frac{F r^2}{m_1 m_2}$$

Therefore, the units of G are given by

$$\frac{(\text{kg m s}^{-2}) \text{ m}^2}{\text{kg kg}} = \text{m}^3 \text{ kg}^{-1} \text{ s}^{-2}$$

Alternatives B, C and D all have more than one index wrong.

References:

Haber-Schaim, 4th ed., p. 295.
Ingram, Part 1, p. 110.
Mayfield, Book 1, pp. 82, 83.
Project Physics, Unit 2, p. 101.
Williams, p. 104.

3 Correct Response: C

Discussion:

The gravitational force, F , on a mass m can be expressed as $F = \frac{G M_E m}{R^2}$, where M_E is the mass of the earth and the other terms are as defined in question 1.

If this is the only force acting, the acceleration due to gravity, g_r , can be obtained as follows:

$$\text{Resultant force} = m \times a$$

$$\frac{G M_E m}{R^2} = m \times g_r$$

$$g_r = \frac{G M_E}{R^2}$$

$$\text{Therefore } g_r = \frac{G M_E}{R^2} \quad \frac{G M_E}{r^2}$$

$$\text{that is } \frac{g_r}{R^2} = \frac{r^2}{R^2} \quad (\text{Alternative C})$$

References:

Haber-Schaim, 4th ed., p. 292.
Ingram, Part 1, pp. 110–113.
Mayfield, Book 1, p. 81.
Williams, p. 105.

4 Correct Response: D

Discussion:

Kepler was involved in the reduction of data collected by Tycho Brahe and formulated scientific explanation to fit that data.

Alternatives A and B could relate to Tycho Brahe.

References:

Haber-Schaim, 4th ed., pp. 281–285.
Mayfield, Book S8.
Project Physics, Unit 2, pp. 55–57.
Williams, p. 40.

5 Correct Response: A

Discussion:

The law of gravitation is a causal law, in that it attempts to explain and predict the interaction of masses. The other laws are very perceptive summations of data and can all be deduced from the law of gravitation.

Hence alternative A is the correct response.

References:

Haber-Schaim, 4th ed., pp. 285–288.
Project Physics, Unit 2, pp. 57–69.

6 Correct Response: B

Discussion:

Kepler's third law states that $\frac{R^3}{T^2}$ is constant for all masses revolving around the same central mass, where R is the average radius of the mass' orbit and T is the period of the orbit.

Using T or N to refer to either Triton and Nereid respectively, then

$$\frac{R_T^3}{T_T^2} = \frac{R_N^3}{T_N^2}$$

$$\Rightarrow \frac{R_T^3}{R_N^3} = \frac{T_T^2}{T_N^2}$$

$$\Rightarrow \frac{R_T}{R_N} = \sqrt[3]{\frac{T_T^2}{T_N^2}}$$

Now $T_T = 5.8$ days, $T_N = 360$ days,

$$\text{So } \frac{R_T}{R_N} = \sqrt[3]{\left(\frac{5.8}{360}\right)^2}$$

References:

Haber-Schaim, 4th ed., pp. 283-285.

Ingram, Part 1, p. 109.

Mayfield, Book S8.

Project Physics, Unit 2, p. 66.

7 Correct Response: C

Discussion:

The relation $T^2 = kR^3$ is true for all planets revolving around a central mass. Hence, the only factor that can change k is the central mass, the star itself. This can also be verified by deriving Kepler's third law from consideration of the law of gravitation, and knowing that the gravitational force is the necessary centripetal force keeping the planet in motion.

If G = universal gravitational constant

m_p = mass of planet,

m_s = mass of star,

T = period of motion, and

R = distance between the centres of mass of the star and planet, then

$$F = \frac{G m_p m_s}{R^2}$$

$$= m_p \frac{4\pi^2 R}{T^2}$$

$$G m_s = \frac{4\pi^2 R^3}{T^2}$$

$$T^2 = \frac{4\pi^2}{G m_s} R^3$$

$$\text{so } k = \frac{4\pi^2}{G m_s}$$

References:

Haber-Schaim, 4th ed., pp. 289-292.

Ingram, Part 1, p. 109.

Mayfield, Book S8.

Project Physics, Unit 2, p. 66.

8 Correct Response: D

Discussion:

Using Kepler's third law,

$$\frac{r_x^3}{T_x^2} = \frac{r_y^3}{T_y^2}$$

rearranging

$$\frac{T_x^2}{T_y^2} = \frac{r_x^3}{r_y^3}$$

$$\frac{T_x}{T_y} = \sqrt{\frac{r_x^3}{r_y^3}}$$

$$= \sqrt{\left(\frac{r_x}{r_y}\right)^3}$$

However,

$$\frac{r_x}{r_y} = \frac{1}{3}$$

so

$$\frac{T_x}{T_y} = \sqrt{\left(\frac{1}{3}\right)^3}$$

$$= \sqrt{\frac{1}{27}}$$

$$= \frac{1}{3\sqrt{3}}$$

Selection of alternative A indicates an arithmetical

error, or that the ratio $\frac{T_y}{T_x}$ has been calculated.

Alternative B shows both an arithmetical error and an index error, while choosing alternative C indicates an index error.

References:

Haber-Schaim, 4th ed., pp. 283-285.

Ingram, Part 1, p. 109.

Mayfield, Book S8.

Project Physics, Unit 2, p. 66.

9 Correct Response: B

Discussion:

Now orbital speed $v = \frac{\text{circumference}}{\text{period}} = \frac{2\pi r}{T}$

that is, $v = \frac{2\pi r}{T}$

thus, $\frac{v_x}{v_y} = \frac{r_x \cdot T_y}{r_y \cdot T_x} = \left(\frac{r_x}{r_y}\right) \cdot \left(\frac{T_y}{T_x}\right)$

but $\frac{r_x}{r_y} = \frac{1}{3}$ (given information)

and $\frac{T_y}{T_x} = 3\sqrt{3}$ (from item 8)

so $\frac{v_x}{v_y} = \frac{1}{3} \cdot 3\sqrt{3} = \sqrt{3}$

that is, $\frac{v_x}{v_y} = \sqrt{3}$

References:

Haber-Schaim, 4th ed., p. 212.
Ingram, Part 1, pp. 26, 109, 232.
Mayfield, Book 1, p. 31.

10 Correct Response: A

Discussion:

The acceleration of the planets can be calculated in two ways, namely

- (i) from the orbital speed, using $a = \frac{v^2}{r}$, or
- (ii) from the period, using $a = \frac{4\pi^2 r}{T^2}$.

Using method (i) gives

$$\begin{aligned} \frac{a_x}{a_y} &= \frac{v_x^2}{r_x} \cdot \frac{r_y}{v_y^2} \\ &= \left(\frac{v_x}{v_y}\right)^2 \cdot \frac{r_y}{r_x} \\ &= \left(\frac{\sqrt{3}}{1}\right)^2 \cdot 3 \\ &= 9 \end{aligned}$$

Using method (ii) gives

$$\begin{aligned} \frac{a_x}{a_y} &= \frac{r_x}{T_x^2} \cdot \frac{T_y^2}{r_y} \\ &= \left(\frac{r_x}{r_y}\right) \cdot \left(\frac{T_y}{T_x}\right)^2 \\ &= \frac{1}{3} \cdot (3\sqrt{3})^2 \\ &= \frac{27}{3} \\ &= 9 \end{aligned}$$

Alternative C follows if D was chosen as the result in item 9, while alternative D is simply the reciprocal of the correct answer.

References:

Haber-Schaim, 4th ed., p. 212.
Ingram, Part 1, pp. 28, 109–111, 232.
Mayfield, Book 1, p. 30.
Project Physics, Unit 2, p. 90.

11 Correct Response: D

Discussion

The calculation of this ratio is based on Kepler's third law, $r^3 = k T^2$, where k is fixed for a particular central body. If another star is chosen to be the central body, then the value of k is changed. Hence, alternative D is the correct response. This item reinforces item 7.

References:

Haber-Schaim, 4th ed., pp. 289–292.
Ingram, Part 1, p. 109.
Project Physics, Unit 2, p. 66.

12 Correct Response: C

Discussion:

From Newton's third law, it can be seen that the force on the moon due to Earth is equal and opposite to the force on Earth due to the moon. This can also be seen in Newton's Law of Gravitation, which states that the gravitational force is proportional to the product of the masses. Hence alternative C is the correct response.

References:

Haber-Schaim, 4th ed., p. 319.
Ingram, Part 1, p. 73.
Mayfield, Book 1, p. 82.
Project Physics, Unit 2, p. 100.
Williams, p. 103.

13 Correct Response: A

Discussion:

There are two forces acting on the earth. Firstly, there is the gravitational attraction from the man which is upwards, and secondly a reaction force from the man which is downwards. This reaction force is apparent in the tension in the legs and is a result of the earth's attraction of the man's mass. The net resultant force exerted on the earth is therefore zero.

References:

Haber-Schaim, 4th ed., p. 318.
Mayfield, Book 1, p. 43.
Project Physics, Unit 1, pp. 83–87.
Williams, pp. 103–105.

14 Correct Response: A**Discussion:**

Assuming the satellite's orbit is circular, the force derived from Newton's law of gravitation can be equated to the centripetal force. Thus

$$\frac{G m_u m_A}{R^2} = \frac{m_A 4\pi^2 R}{T^2}$$

where m_u = mass of Uranus

and m_A = mass of Ariel

Hence,
$$m_u = \frac{4\pi^2 R^3}{T^2 G}$$

$$\approx \frac{4 \cdot 10 \cdot (1.9 \times 10^8)^3}{(2.2 \times 10^5)^2 \cdot 6.7 \times 10^{-11}}$$

$$\Rightarrow m_u \approx 8.4 \times 10^{25}$$

References:

Haber-Schaim, 4th ed., p. 290-292.

Ingram, Part 1, pp. 109-111.

Mayfield, Book S8.

Project Physics, Unit 2, pp. 102-104.

15 Correct Response: C**Discussion:**

The gravitational force exerted on X by Y is equal and opposite to the gravitational force exerted on Y by X . Hence C is the correct alternative. (See also item 12.)

References:

Haber-Schaim, 4th ed., p. 319.

Ingram, Part 1, p. 73.

Mayfield, Book 1, p. 82.

Project Physics, Unit 1, p. 86; Unit 2, p. 100.

Williams, p. 103.

16 Correct Response: D**Discussion:**

The gravitational force is proportional to the product of the masses. That is

$$F_{xy} \propto m_x m_y$$

If the mass of x , m_x , is doubled, then F_{xy} is doubled, so the resulting force would be $2F$.

References:

Haber-Schaim, 4th ed., p. 291.

Ingram, Part 1, p. 108.

Mayfield, Book 1, p. 82.

Project Physics, Unit 2, p. 100.

Williams, p. 103.

17 Correct Response: A**Discussion:**

The gravitational force between the two masses X and Y is F_{xy} , given by

$$F_{xy} = \frac{G m_x m_y}{R^2}$$

where R is the distance between the centres of mass of the two masses, X and Y .

So,
$$F_{xy} \propto \frac{1}{R^2}$$

Hence if the distance is doubled, the magnitude of the force is reduced by a factor of 4.

References:

Haber-Schaim, 4th ed., pp. 290, 291.

Ingram, Part 1, p. 108.

Mayfield, Book 1, p. 82.

Project Physics, Unit 2, p. 100.

Williams, p. 103.

18 Correct Response: B**Discussion:**

Since the gravitational force $F_{xy} \propto \frac{m_x}{R^2}$, then the new force when both changes are made will be altered by a factor of $\frac{2}{2^2} = \frac{1}{2}$. That is, the new force will be $\frac{F}{2}$.

References:

Haber-Schaim, 4th ed., pp. 290, 291.

Ingram, Part 1, p. 108.

Mayfield, Book 1, p. 82.

Project Physics, Unit 2, p. 100.

Williams, p. 103.

19 Correct Response: B

Discussion:

As has been shown earlier (see discussion for item 14), when a large mass M_1 has a smaller mass m_1 revolving around it at a distance of R , then the gravitational force can be combined with the centripetal force such that

$$F = \frac{G M_1 m_1}{R^2} = m_1 a = \frac{m_1 4\pi^2 R}{T_1^2}$$

where T_1 is the period of the motion of the satellite m_1 around M_1 .

Hence
$$M_1 = \frac{4\pi^2 R^3}{T_1^2 G}$$

Similarly,
$$M_2 = \frac{4\pi^2 R^3}{T_2^2 G}$$

Consequently,
$$\frac{M_1}{M_2} = \left(\frac{T_2}{T_1}\right)^2$$

Now
$$T_1 = 2T_2$$

Hence
$$\frac{M_1}{M_2} = \frac{1}{4}$$

References:

Haber-Schaim, 4th ed., pp. 290, 291.

Ingram, Part 1, pp. 109–111, 232.

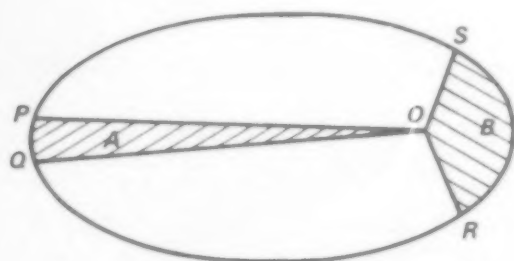
Mayfield, Book S8.

Project Physics, Unit 2, p. 102.

20 Correct Response: B

Discussion:

Kepler's second law states that the areal velocity of a planet around a star is constant, that is the planet sweeps out equal areas in equal times.



If the area A equals area B , then the time for the planet to move from P to Q equals the time for it to travel from R to S . Hence the planet travels at its fastest speed when its position is closest to the star. (Alternative B).

References:

Haber-Schaim, 4th ed., p. 283.

Mayfield, Book S8.

Project Physics, Unit 2, pp. 57–65.

21 Correct Response: D

Discussion:

Alternative A is incorrect as such a situation would encourage the escape of the molecules of the atmosphere.

Alternative B is irrelevant, and C also would make it easier for the upper atmosphere to escape from the earth.

Alternative D is the correct response as it states that the velocity of escape will not normally be attained by the molecules of the atmosphere—hence the earth retains its atmosphere.

References:

Haber-Schaim, 4th ed., pp. 358–360.

Mayfield, Book S8.

22 Correct Response: C

Discussion:

As shown earlier it can be stated that gravitational attraction between Quirius and a planet

$$= F_{QP} = \frac{G M_Q M_P}{R^2}$$

where G = universal constant of gravitation

M_Q = mass of Quirius

M_P = mass of planet, and

R = mean orbital radius.

Hence for planets I and III,

$$\begin{aligned} \frac{F_{QI}}{F_{QIII}} &= \frac{G M_Q M_I}{R_I^2} \cdot \frac{R_{III}^2}{G M_Q M_{III}} \\ \frac{F_{QI}}{F_{QIII}} &= \frac{G M_Q M_I}{R_I^2} \cdot \frac{(9R_I)^2}{G M_Q 4M_I} \\ &= \frac{9^2}{4} \end{aligned}$$

thus
$$\frac{F_{QI}}{F_{QIII}} = \frac{81}{4}$$

References:

Haber-Schaim, 4th ed., pp. 290, 291.

Ingram, Part 1, p. 108.

Mayfield, Book 1, p. 82.

Project Physics, Unit 2, p. 100.

Williams, p. 103.

23 Correct Response: E**Discussion:**

The periods of *rotation* of planets are not simply related to the parameters of planet mass and mean radius. Alternative **D** is obtained if Kepler's third law is used to determine a period, T_{III} . But this T_{III} is the period of the *revolution* of planet III about Quirius, and not the period of *rotation* of planet III about its own axis. Not enough information is given to determine the period of rotation, so alternative **E** is the required answer.

References:

Haber-Schaim, 4th ed., pp. 281-287.
Project Physics, Unit 2, p. 66.

24 Correct Response: B**Discussion:**

Applying Kepler's third law,

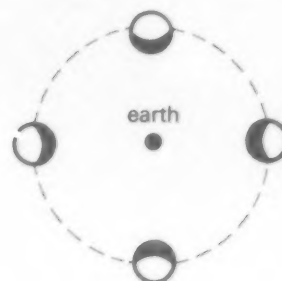
$$R^3 = k T^2$$

to this situation, gives,

$$\begin{aligned}\frac{T_{IV}}{T_I} &= \left(\frac{R_{IV}}{R_I}\right)^{\frac{3}{2}} \\ T_{IV} &= \left(\frac{16R_I}{R_I}\right)^{\frac{3}{2}} \cdot T_I \\ &= 16^{\frac{3}{2}} \cdot 1 \text{ dings} \\ &= 64 \text{ dings}\end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 285.
Ingram, Part I, p. 109.
Mayfield, Book S8.
Project Physics, Unit 2, p. 66.

25 Correct Response: C**Discussion:**

In the diagram, the moon is shown rotating on its own axis in a counter clockwise direction. The moon only comes back to the same orientation relative to the stars after one revolution of the earth.

Hence, for the moon, the period of rotation is equal to the period of revolution about the earth.

(Alternative C)

References:

Haber-Schaim, 4th ed., pp. 262, 265, 266.
Mayfield, Book S8.

26 Correct Response: B**Discussion:**

Alternative **A** is incorrect as there would be insufficient energy released in the process. Similarly for alternative **D**, there would again be insufficient energy released. Alternative **C** is also incorrect as this condition would occur after the high temperature is reached.

Alternative **B** is the correct response.

References:

Haber-Schaim, 4th ed., pp. 357-362.
Mayfield, Book S8.

ACER PHYSICS UNIT TESTS

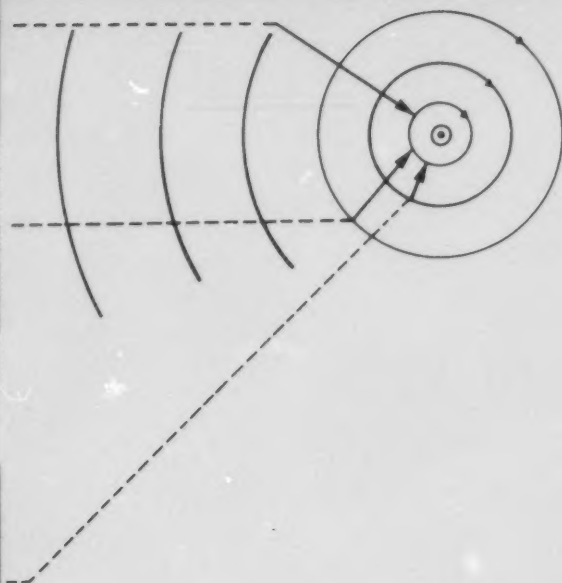
The ACER Physics Unit Tests consist of the following publications.

I A collection of tests covering the following topics

- 1 *Physical measurement*
- 2 *Vectors*
- 3 *Motion in one dimension*
- 4 *Motion on a plane*
- 5 *Dynamics*
- 6 *Work and energy*
- 7 *Linear momentum*
- 8 *Oscillations*
- 9 *Gravity and Kepler's laws*
- 10 *Waves*
- 11 *Light — reflection and refraction*
- 12 *Light — interference, diffraction and spectra*
- 13 *Models of light*
- 14 *Kinetic theory of gases*
- 15 *Static charges*
- 16 *Electric field and potential difference*
- 17 *Current electricity*
- 18 *The magnetic field*
- 19 *Induced EMF*
- 20 *Atomic physics*
- 21 *Quantum physics*

II A collection of 21 Diagnostic Aids covering topics corresponding to the tests.

III Teachers Handbook



Diagnostic Aid 10 Waves

Description

This diagnostic aid is one of a collection of 21 diagnostic aids corresponding to the 21 separate tests in the *Physics Unit Tests*.

In each diagnostic aid an explanation is provided so that the reasons why the responses are correct or incorrect are available to you.

To gain maximum benefit from the *Physics Unit Tests* weaknesses diagnosed need to be followed up. These diagnostic aids make it possible for you to proceed with this follow up in your own time. If you do not understand the discussion you are advised to seek help from your teacher.

References

The references throughout the Diagnostic Aids have been abbreviated. The abbreviations and full publication details are listed.

- Haber-Schaim: Haber-Schaim, U., Cross, J.B., Dodge, J.H., and Walter, J.A. *PSSC Physics*. 4th ed. Lexington, Mass.: D.C. Heath, 1976. (Reference is also made to 3rd ed.)
- Ingram: Ingram, A.D., Kuhl, D.H., McCarthy, I.E., Sandercock, E.R., Smith, W.F., and Waite, P.J. *Physics: A Laboratory-oriented Approach*. (Study Guide Leaving Part 1, Study Guide Matriculation Part 2). Adelaide: Rigby, 1971, 1972.
- Mayfield: Mayfield, J.M. Parham, R.T., and Webber, B.J. *Fundamentals of Senior Physics*. (Book 1, Book 2). Melbourne: Heinemann Educational Australia Pty Ltd, 1973.
- Project Physics: *Project Physics Course: Programmed Instruction Books* (Kinetic Molecular Theory of Gases, Waves 1-2, Equations 1-3, Vectors 1-3); *Text and Handbook* (Units 1-6). Sydney: Martin Educational, 1970.
- Williams: Williams, J.E., Trinklei, F.E., Metcalfe, H.C., and Lefler, R.W. *Modern Physics*. New York: Holt, Rinehart, & Winston, 1976.

The Australian Council for Educational Research Limited thanks the following publishers for donating textbooks used in referencing the aids: Heinemann Educational Australia Pty Ltd, Richmond, Victoria, for *Fundamentals of Senior Physics*. Rigby Limited, Box Hill, Victoria, for *Physics: A Laboratory-oriented Approach*.

Do not write on this booklet

1 Correct Response: C**Discussion:**

Periodic wave motion is a disturbance which repeats itself at equal time intervals. The time interval, T , during which the disturbance repeats itself, is called the period. Such motion can also be described in terms of the number of times it is repeated in a unit time interval. This is known as the frequency, f . Consider a wave which has a frequency of 5 Hz. The motion is repeated five times in each second. The time interval after which it repeats itself is $\frac{1}{5 \text{ s}^{-1}}$. Thus the period is 0.2 s.

In general, $T = \frac{1}{f}$.

References:

Haber-Schaim, 4th ed., p. 113.
Ingram, Part 2, p. 46.
Mayfield, Book 2, p. 56.
Project Physics, Unit 3, pp. 110–112.
Williams, Sect. 10.6.

2 Correct Response: C**Discussion:**

Consider periodic straight waves moving across a ripple tank. The distance between two adjacent crests is equal to the wavelength. In the time for a complete vibration of the wave generator each crest will have moved to the position of the previously formed crest, that is, a distance of one wavelength.

References:

Haber-Schaim, 4th ed., p. 113.
Ingram, Part 2, p. 46.
Mayfield, Book 2, p. 71.
Project Physics, Unit 3, pp. 110–112.
Williams, Sect. 10.6.

3 Correct Response: B**Discussion:**

From the information given, it can be seen that in 8 seconds each wave moves a distance of 12 metres.

Now, speed of waves, $v = \frac{\text{distance travelled}}{\text{time taken}}$

therefore,
$$v = \frac{12 \text{ m}}{8 \text{ s}} = 1.5 \text{ m s}^{-1}$$

Alternatively, for periodic wave motion, $v = f\lambda$ where f is the frequency and λ is the wavelength.

However $f = \frac{1}{T}$, where T is the period.

Thus,
$$v = \frac{\lambda}{T} = \frac{12 \text{ m}}{8 \text{ s}} = 1.5 \text{ m s}^{-1}$$

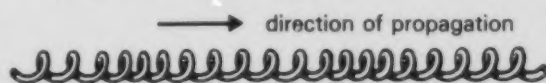
References:

Haber-Schaim, 4th ed., p. 113.
Ingram, Part 2, p. 46.
Mayfield, Book 2, p. 77.
Project Physics, Unit 3, pp. 110–112.
Williams, Sect. 10.6.

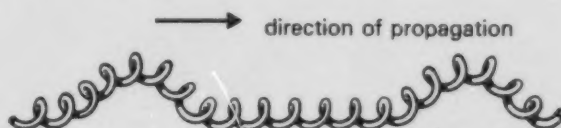
4 Correct Response: A**Discussion:**

By definition, for longitudinal waves, the disturbance is parallel to the direction of propagation (Alternative A). Sound waves are an example of this type of disturbance.

Longitudinal waves can also be demonstrated in a coil spring, as shown in the diagram below:



However, with transverse waves, the disturbance is perpendicular to the direction of propagation. For example,

**References:**

Ingram, Part 2, p. 47.
Mayfield, Book 2, p. 72; S10 p. 5.
Project Physics, Unit 3, p. 106.
Williams, Sect. 10.4.

5 Correct Response: D**Discussion:**

The nodes of the stationary wave are points which have zero amplitude at all times, and for these points to exist the waves must have the same amplitude. Further, unless the two waves also have the same frequency the nodal points will not remain stationary. So alternative D is the correct response. Clarify this explanation by sketching a series of positions of the waves with various amplitudes and frequencies.

References:

Ingram, Part 2, pp. 79–82.
Mayfield, Book 2, pp. 75, 80; HS12, pp. 46, 47.
Project Physics, Unit 3, pp. 119–122.
Williams, Sect. 10.14.

6 Correct Response: A

Discussion:

As stated in the previous question the waves must have the same amplitude for stationary nodal points to occur. The two travelling waves must also be travelling in opposite directions for these stationary nodes to be formed.

Suppose the waves were travelling in the same direction. Since two waves travelling in the same medium must therefore travel at the same speed, then any nodes formed would travel at the same speed as each of the waves and a standing wave would not be formed.

References:

Ingram, Part 2, pp. 79–82.
Mayfield, Book 2, pp. 80, 81; HS12, pp. 46, 47.
Project Physics, Unit 3, pp. 119–122.
Williams, Sect. 10.16.

7 Correct Response: C

Discussion:

If two wave sources are coherent then there is a constant phase relationship between them and therefore a relationship between the frequencies of the two waves.

References:

Ingram, Part 2, pp. 88, 89.
Mayfield, Book 2, p. 112.

8–10 Correct Responses: 8 B

9 D

10 C

Discussion:

Points on nodal lines can be found where a crest from one source meets a trough from another. When two point sources are in phase these points P are formed when the path difference

$$PS_1 - PS_2 = (n - \frac{1}{2})\lambda,$$

where S_1, S_2 represent the two sources, λ is the wavelength and the point P is on the n th nodal line from the perpendicular bisector of the line drawn between the two sources.

When there is a constant phase difference of one half between the sources the points P on nodal lines are found where $PS_1 - PS_2 = n\lambda$. These points occur where the antinodes are when the sources are in phase (Alternative B, item 8).

A good way of understanding how this interference occurs is to draw diagrams using concentric circles to represent crests and dotted concentric circles to represent troughs. Where a crest meets a trough there will be a nodal point. Having found several nodal points the nodal lines can be sketched.

9 When the two sources are in phase, but have different amplitudes there is still an interference pattern similar to the one shown, but there will not be complete cancellation at the nodal lines. Draw some diagrams to find out precisely what you would expect to see.

10 When the sources have different frequencies there will be a continually changing phase difference which must produce a changing interference pattern. (Alternative C.)

References:

Haber-Schaim, 4th ed., p. 130.
Ingram, Part 2, pp. 85–88.
Mayfield, Book 2, p. 100.
Project Physics, Unit 3, pp. 144–119.
Williams, Sect. 10.15.

11–13 Correct Responses: 11 C

12 A

13 A

Discussion:

11 The behaviour of the waves in the mantle is similar to the behaviour of light rays passing through the earth's atmosphere where the refractive index increases as the density of the atmosphere increases. The density of the earth's mantle is also changing, causing a corresponding change in the refractive index for the longitudinal waves, and therefore the direction of the waves changes (alternative C).

12 When the waves meet the boundary between the mantle and the core there is a more sudden change of density and the waves are refracted. On drawing a normal to the boundary it can be seen that the waves are bending towards the normal. This is consistent with an increase in the refractive index and it would be expected that the waves would travel more slowly in the core (alternative A).

13 The shadow region surrounding point III does not experience any of these waves because of the refraction which occurs when the waves enter the mantle—liquid core interface. If there were no liquid core one would expect the wave passing through point II to travel towards the shadow region near point III (alternative A).

References:

Haber-Schaim, 4th ed., pp. 44–52, 116–118.
Ingram, Part 2, pp. 56–60.
Mayfield, Book 2, p. 86.
Project Physics, Unit 3, pp. 124, 130–132.
Williams, Sect. 10.12.

14 and 15 Correct Responses: 14 B

15 A

Discussion:

- 14** Diffraction is the bending of waves as they travel past an obstacle or through a narrow opening.
- 15** Experiments can be performed in a ripple tank to demonstrate that the amount of bending increases as the frequency decreases. The waves therefore would have a more pronounced curvature.

References:

Haber-Schaim, 4th ed., pp. 120–123.
 Ingram, Part 2, pp. 95–100.
 Mayfield, Book 2, p. 104.
 Project Physics, Unit 3, pp. 124–126.
 Williams, Sect. 10.13.

16 Correct Response: B

Discussion:

When two notes of nearly the same frequency are sounded together a regular variation in loudness occurs. This phenomenon is called beats. The frequency of the beats is equal to the difference between the frequencies of the two notes. This can be shown mathematically.

The amplitude of waves of frequency f_1 can be expressed as

$$y_1 = A \sin 2\pi f_1 t$$

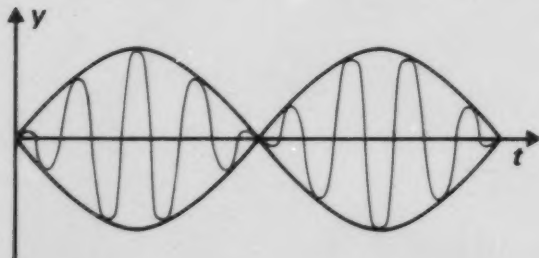
The amplitude of waves of frequency f_2 can be expressed as

$$y_2 = A \sin 2\pi f_2 t$$

Here it has been assumed that the waves have the same maximum amplitude A , as is the case in this problem. When these two waves are produced together the net disturbance is given by

$$\begin{aligned} y_1 + y_2 &= A \sin 2\pi f_1 t + A \sin 2\pi f_2 t \\ &= A (\sin 2\pi f_1 t + \sin 2\pi f_2 t) \\ &= 2A \sin \frac{2\pi(f_1 + f_2)t}{2} \cos \frac{2\pi(f_1 - f_2)t}{2} \end{aligned}$$

The resultant wave pattern is of the form shown below.



Since the unloaded tuning fork will have the greater frequency, let its frequency be f_1 and the frequency of the loaded tuning fork be f_2 .

The beat frequency is $f_1 - f_2 = 3$ cps.

Thus $f_2 = 177$ cps.

References:

Ingram, Part 2, pp. 84, 85.
 Mayfield, Book 2, p. 79; S10 p. 37; HS 12 pp. 39, 40.
 Williams, Sect. 11.17.

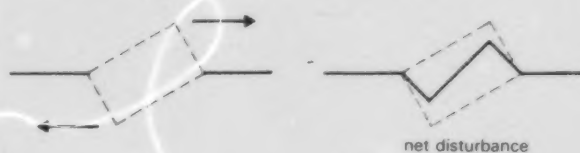
17 Correct Response: D

Discussion:

The best approach to answer this question is to draw the pulses while they are interacting.

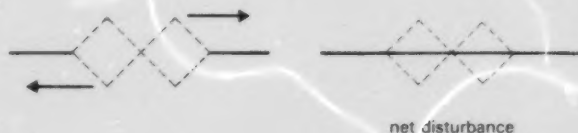
It is immediately apparent that the pulses in alternative B and C will not cancel completely.

Drawing the pulses for alternative A gives:



It can be seen that these two pulses will not completely cancel.

Finally, D gives



These two pulses will completely cancel.

References:

Haber-Schaim, 4th ed., p. 95.
 Ingram, Part 2, pp. 48, 49.
 Mayfield, Book 2, p. 75.
 Project Physics, Unit 3, pp. 113, 114.
 Williams, Sect. 10.14.

18-21 Correct Responses: 18 A

19 B

20 C

21 D

Discussion:

The pulses generated at S_1 and S_2 are travelling at 5 m s^{-1} and for such a pulse one metre long we need to calculate how long it takes the leading edge of the pulse to travel one metre, as this will show how long it takes to form the whole pulse.

$$t = \frac{d}{v}$$

$$= \frac{1 \text{ m}}{5 \text{ m s}^{-1}}$$

$$= 0.2 \text{ s} \quad (\text{Alternative A, item 18})$$

- 19 To travel from S_1 to P, a distance of 10 m, a pulse will take time

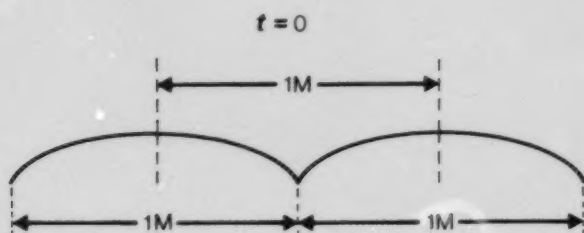
$$t = \frac{d}{v}$$

$$= \frac{10 \text{ m}}{5 \text{ m s}^{-1}}$$

$$= 2 \text{ s} \quad (\text{Alternative B})$$

- 20 As the pulse generated at S_1 approaches P it can be seen that the point P will firstly rise to a maximum displacement of 0.5 m and then fall to a displacement of zero. The point P will commence rising at $t = 2 \text{ s}$ since the leading edge of the pulse was initiated at $t = 0$. Since the pulse is one metre long it will take 0.2 s (see item 18) for the point P to complete its motion (Alternative C).

- 21 When two pulses are generated, one at S_1 and one at S_2 their leading edges will commence interacting at P at $t = 0$ and the displacement at P will begin increasing.



Since the pulses are symmetrical and travelling at the same speed, it can be seen that after time $t = 0$ each pulse will travel 0.5 m before the maxima meet and the maximum net displacement occurs.

This maximum displacement at P will therefore occur at time

$$t = \frac{0.5 \text{ m}}{5 \text{ m s}^{-1}}$$

$$= 0.1 \text{ s}$$

Thus alternative D is the best representation of the displacement at P.

References:

Haber-Schaim, 4th ed., p. 95.
Ingram, Part 2, pp. 48, 49.
Mayfield, Book 2, pp. 72-78.
Project Physics, Unit 3, pp. 113, 114.
Williams, Sects. 10.6, 10.14.

22 and 23 Correct Responses: 22 D

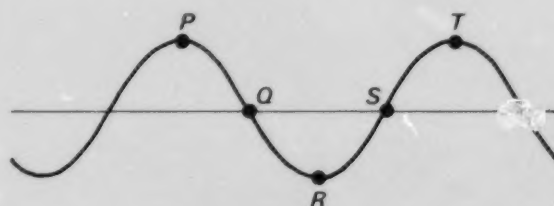
23 A

Discussion:

At the point P we have two peaks meeting, each of equal amplitude, a . The superposition principle states that the resultant amplitude due to the two peaks meeting will be $a + a = 2a$.

(Alternative D, item 22.)

To determine the amplitude of the resultant motion at Q, consider the cross-section of the waves from X and Y.



cross section of the waves from X



cross section of the waves from Y

At Q we have zero displacement due to the waves from X and zero displacement due to the waves from Y. The net displacement is therefore zero.

References:

Haber-Schaim, 4th ed., pp. 130-133.
Ingram, Part 2, pp. 48, 49, 85-87.
Project Physics, Unit 3, pp. 113, 114.
Williams, Sect. 10.15.

24 Correct Response: D

Discussion:

The number of nodal lines in a two source interference pattern is determined by the ratio $\frac{\lambda}{d}$ where d is the distance between the sources and λ is the wavelength. The number of nodal lines increases as the ratio $\frac{\lambda}{d}$ decreases.

The number of nodal lines can be determined mathematically. For a point P on the n th nodal line $PS_1 - PS_2 = (n - \frac{1}{2})\lambda$.

The maximum value of $PS_1 - PS_2$ is d , the separation

$$PS_1 - PS_2 < d$$

$$\text{and so } (n - \frac{1}{2})\lambda < d$$

$$\text{and } n - \frac{1}{2} < \frac{d}{\lambda}$$

For example, when $d = 2\lambda$, $n - \frac{1}{2} < 2$, so the maximum value of n is 2. Therefore there are two nodal lines on each side of the line of symmetry in front of the sources.

When $d = 4\lambda$

$$n - \frac{1}{2} < 4$$

so the maximum value of n is 4.

Therefore there should be 8 nodal lines in the diagram.

References:

Haber-Schaim, 4th ed., pp. 134-138, 141.

Ingram, Part 2, pp. 85-90.

Project Physics, Unit 3, p. 114-119.

Williams, Sect. 10.15.

25-27 Correct Responses: 25 B

26 C

27 B

Discussion:

When considering points on nodal lines at large distances from two coherent point sources it can be shown that

$$x_n = (n - \frac{1}{2})L \frac{\lambda}{d}$$

where x_n is the distance from the perpendicular bisector of the line between the two sources to the point on the n th node,

L is the distance from the point on the nodal line to the centre of the line between the sources,

d is the distance between the sources, and

λ is the wavelength.

The spacing, Δx , between adjacent nodes can then be expressed as

$$\Delta x = L \frac{\lambda}{d}$$

The nodal spacing 15 m from the sources is 10 m.

$\Delta x \propto L$ for a given λ and d , so at a distance of 20 m from the sources

$$\begin{aligned} \Delta x &= \frac{20}{15} \times 10 \text{ m} \\ &= 13.3 \text{ m} \end{aligned} \quad (\text{Alternative B, item 25})$$

26 The wavelength can be expressed as

$$\begin{aligned} \lambda &= \frac{\Delta x}{L} \times d \\ &= \frac{10 \text{ m}}{15 \text{ m}} \times 2 \text{ m} \\ &= 1.33 \text{ m} \end{aligned} \quad (\text{Alternative C})$$

27 When we triple the frequency in the same medium, the wavelength is changed by a factor of $\frac{1}{3}$ and so again using the above relation it can be seen that the spacing will also be changed by a factor of $\frac{1}{3}$. ($\Delta x \propto \lambda$ for a given L, d)

The spacing Δx becomes $\frac{10 \text{ m}}{3}$.

References:

Haber-Schaim, 4th ed., p. 147.

Ingram, Part 2, pp. 85-90.

Mayfield, Book 2, pp. 98-101.

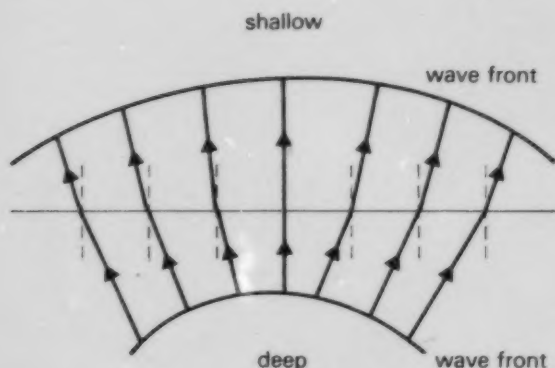
Project Physics, Unit 3, pp. 114-119.

Williams, Sect. 10.15.

28 Correct Response: B

Discussion:

On refraction the circular wave crests will slow down and also bend towards the normal to the boundary between the deep and shallow water. A few sketches of the waves as they cross the boundary will demonstrate that the curvature of the waves will decrease as a result.



References:

Haber-Schaim, 4th ed., p. 116.
Ingram, Part 2, pp. 56-60.
Mayfield, Book 2, pp. 94-97.
Project Physics, Unit 3, p. 131.
Williams, Sect. 10.12.

**29 and 30 Correct Responses: 29 A
30 D**

Discussion:

Given that $PS_1 = PS_2$, then it can be clearly seen that when S_1 and S_2 are in phase, a crest from S_1 will arrive at P at the same time as a crest from S_2 and troughs from each source will also arrive at the same time. Thus at the point P there will be a displacement varying between $+2$ m and -2 m. The frequency of these double crests and double troughs will be

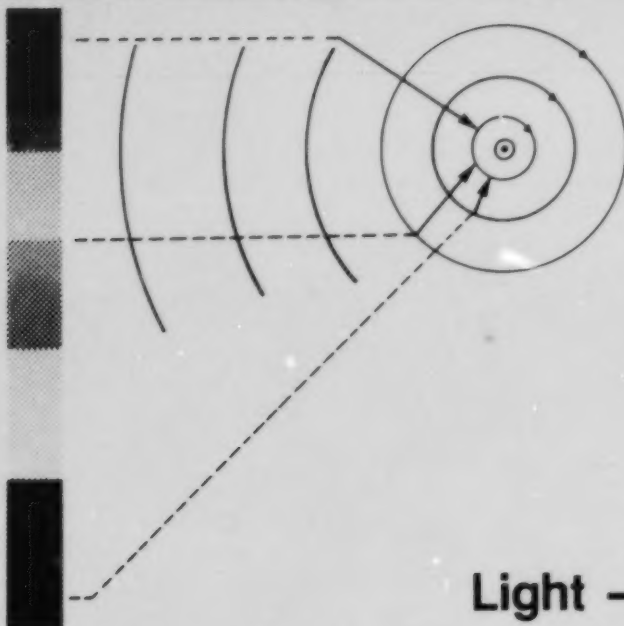
$$\frac{v}{\lambda} = \frac{8 \text{ m s}^{-1}}{2 \text{ m}} = 4 \text{ s}^{-1}.$$

Thus, the resultant motion at P will have a period of $\frac{1}{4 \text{ s}^{-1}}$, that is 0.25 s. Hence, graph A is the correct response for item 29.

When the phase difference is one half, a crest from S_1 will arrive at P at the same time as a trough from S_2 , since $PS_1 = PS_2$. Also, a trough from S_1 will arrive at P at the same time as a crest from S_2 . Therefore, P will be a node. (Graph D, item 30.) However, it may immediately be recognised that the path difference is zero, and therefore when the sources are in phase there will be a maximum disturbance and when the phase delay is one half there will be a node.

References:

Haber-Schaim, 4th ed., pp. 130-133, 138-141.
Ingram, Part 2, pp. 85-90.
Mayfield, Book 2, pp. 78, 79.
Project Physics, Unit 3, pp. 114-119.
Williams, Sect. 10.14.



Diagnostic Aid 11

Light — reflection and refraction

Description

This diagnostic aid is one of a collection of 21 diagnostic aids corresponding to the 21 separate tests in the *Physics Unit Tests*.

In each diagnostic aid an explanation is provided so that the reasons why the responses are correct or incorrect are available to you.

To gain maximum benefit from the *Physics Unit Tests* weaknesses diagnosed need to be followed up. These diagnostic aids make it possible for you to proceed with this follow up in your own time. If you do not understand the discussion you are advised to seek help from your teacher.

References

The references throughout the Diagnostic Aids have been abbreviated. The abbreviations and full publication details are listed.

- Haber-Schaim: Haber-Schaim, U., Cross, J.B., Dodge, J.H., and Walter, J.A. *PSSC Physics*. 4th ed. Lexington, Mass.: D.C. Heath, 1976. (Reference is also made to 3rd ed.)
- Ingram: Ingram, A.D., Kuhl, D.H., McCarthy, I.E., Sandercock, E.R., Smith, W.F., and Waite, P.J. *Physics: A Laboratory-oriented Approach*. (Study Guide Leaving Part 1, Study Guide Matriculation Part 2). Adelaide: Rigby, 1971, 1972.
- Mayfield: Mayfield, J.M. Parham, R.T., and Webber, B.J. *Fundamentals of Senior Physics*. (Book 1, Book 2). Melbourne: Heinemann Educational Australia Pty Ltd, 1973.
- Project Physics: *Project Physics Course: Programmed Instruction Books* (Kinetic Molecular Theory of Gases, Waves 1-2, Equations 1-3, Vectors 1-3); *Text and Handbook* (Units 1-6). Sydney: Martin Educational, 1970.
- Williams: Williams, J.E., Trinklei, F.E., Metcalfe, H.C., and Lefler, R.W. *Modern Physics*. New York: Holt, Rinehart, & Winston, 1976.

The Australian Council for Educational Research Limited thanks the following publishers for donating textbooks used in referencing the aids: Heinemann Educational Australia Pty Ltd, Richmond, Victoria, for *Fundamentals of Senior Physics*. Rigby Limited, Box Hill, Victoria, for *Physics: A Laboratory-oriented Approach*.

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1-4 Correct Responses: 1 B

2 B

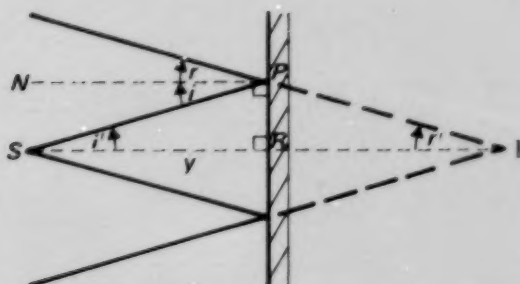
3 B

4 A

Discussion:

The angle of reflection of a light ray from a plane mirror is equal to the angle of incidence, that is $\angle i = \angle r$.

The diagram below shows light rays from a source being reflected by a plane mirror.



In the diagram, NP is parallel to SR

$\Rightarrow i' = i$ and $r' = r$

$\Rightarrow$ triangles PRS and PRI congruent

$\Rightarrow SR = IR$ (Alternative B, item 1)

After reflection the rays diverge and appear to be diverging from a point I behind the mirror. Hence I is the virtual image of source S (alternative B, item 2).

Because $SR = IR$, $SI = 2y$ (item 3) and because of the congruence of triangles PRS and PRI , S and I must move towards the mirror at the same speed, V (alternative A, item 4).

References:

Haber-Schaim, 4th ed., pp. 24-28.

Ingram, Part 2, pp. 53, 54.

Mayfield, Book 2, p. 92; HS7, p. 4.

Project Physics, Unit 4, pp. 11-13.

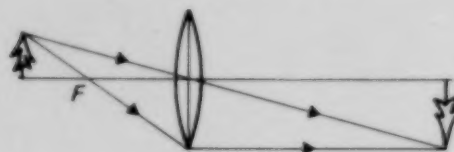
Williams, Sect. 13.4.

5 Correct Response: C

Discussion:

A real image can only be formed by a convex lens.

Two possible images formed by a convex lens are shown in the diagram below.



or



The image is either enlarged or diminished but is always inverted.

References:

Haber-Schaim, 4th ed., pp. 64, 65.

Ingram, Part 2, p. 62.

Mayfield, Book HS7, p. 11.

Williams, Sects. 14.9, 14.10.

6 Correct Response: A

Discussion:

Referring to items 1 to 4, the image of any point source in front of a plane mirror is in the exactly congruent position behind the mirror. Thus the image of any extended object will always be upright.

References:

Haber-Schaim, 4th ed., pp. 24-28.

Ingram, Part 2, p. 54.

Mayfield, Book HS7, p. 11.

Project Physics, Unit 4, p. 11.

Williams, Sect. 13.4.

7 Correct Response: C

Discussion:

Because $\angle i = \angle r$ for all specular reflection (see items 1 to 4) alternative A must be incorrect. Light passing from glass into air is refracted away from the normal (towards the interface) and so B is incorrect.

Alternative C is correct because the refracted ray bends towards the normal, and D is incorrect because the refracted ray must be radial, and therefore perpendicular to the curved interface to avoid a second refraction.

References:

Haber-Schaim, 4th ed., pp. 52-54, 56, 57.
Ingram, Part 2, pp. 57-59.
Mayfield, Book 2, p. 93.
Project Physics, Unit 4, p. 11.
Williams, Sect. 14.4.

8 Correct Response: D

Discussion:

Because the incident ray is attempting to move into a less optically dense medium, at an angle greater than the critical angle, it will be totally internally reflected at an angle equal to the angle of incidence. Thus alternative D is the best response.

References:

Haber-Schaim, 4th ed., pp. 56, 57.
Ingram, Part 2, p. 60.
Williams, Sect. 14.5.

9 Correct Response: C

Discussion:

The three rays all appear to diverge from a point I (see diagram).



Hence, it can be seen that the image is virtual, upright and larger than the object.

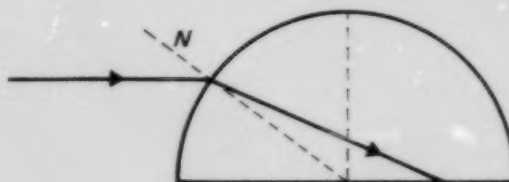
References:

Haber-Schaim, 4th ed., pp. 64, 65.
Mayfield, Book HS7, p. 11.
Williams, Sect. 14.9.

10 Correct Response: D

Discussion:

The refracted ray must bend towards the normal on passing from air into glass, but it cannot refract beyond the normal. Thus A, B and C are all impossible.



The diagram shows a possible refracted ray, and clearly alternative D is the best response.

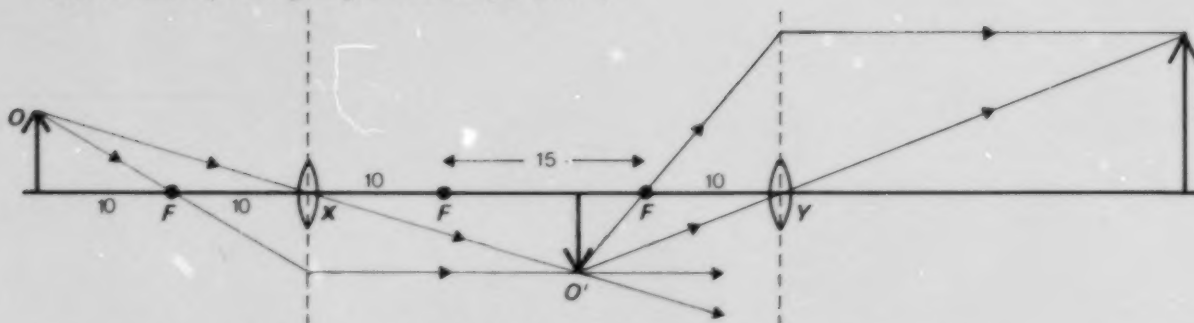
References:

Haber-Schaim, 4th ed., pp. 64, 65.
Ingram, Part 2, pp. 57-59.
Mayfield, Book 2, p. 93.
Williams, Sect. 14.4.

- 11-13 Correct Responses: 11 A
12 A
13 D

Discussion:

The best approach to answer these questions is to draw a scale ray tracing diagram as shown below.



Lens X forms an image O' of object O , and lens Y forms an image I of the new object O' . It can be seen that the image of the object formed by the lens combination is real and upright (item 11).

By scaled measurement, I is twice the height of O (item 12), and is 30 cm to the right of lens Y (alternative D, item 13).

References:

Haber-Schaim, 4th ed., pp. 64, 65.
Mayfield, Book HS7, p. 11.
Williams, Sect. 14.9.

- 14 Correct Response: B

Discussion:

A ray through C should reflect back through C , and hence alternative A is incorrect. B is correct because a ray through F reflects parallel to the axis. Alternative C is incorrect because a ray parallel to the axis should reflect through F , not C , and D indicates a ray passing through the mirror!

References:

Haber-Schaim, 4th ed., pp. 34-38.
Ingram, Part 2, p. 62.
Mayfield, Book HS7, p. 7.
Williams, Sect. 13.9.

- 15-18 Correct Responses: 15 C

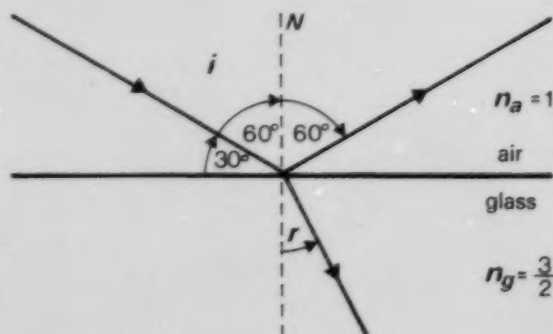
16 B

17 A

18 D

Discussion:

The angle of incidence lies between the normal and the incident ray (see diagram below) and hence the angle of incidence is 60° .



Referring to the diagram and using Snell's Law,

$$\frac{\sin i}{\sin r} = \frac{n_g}{n_a}$$

Thus

$$\frac{\sin 60^\circ}{\sin r} = \frac{3/2}{1}$$

$\Rightarrow$

$$\sin r = \frac{\sqrt{3}}{3} \quad (\text{item 16})$$

Total internal reflection can only occur for light passing from one medium into a less optically dense medium. Hence, the only acceptable alternative is for light passing from glass into water.

(item 17)

- 18 Light travels fastest in the least optically dense medium, and thus $V_G < V_W < V_A$ is the correct response.

References:

Haber-Schaim, 4th ed., p. 52-57.
Ingram, Part 2, pp. 54, 60.
Mayfield, Book 2, p. 93.
Project Physics, Unit 4, p. 11.
Williams, Sects. 13.3, 14.2, 14.5.

19-22 Correct Responses: 19 D

20 A

21 C

22 E

Discussion:

When white light strikes the surface of the slab of red glass, some white light will be reflected (alternative D, item 19), and some will pass into the glass to be refracted and partly absorbed. Nearly all the non-red part of this white light is absorbed, and so the light emerging from the slab of red glass is red (item 20).

When a piece of green glass is inserted it will only transmit green light. Some of this will be reflected and so the nearer image will appear green (alternative C, item 21), and some will be largely absorbed by the red glass and may emerge as a rather weak yellow (item 22).

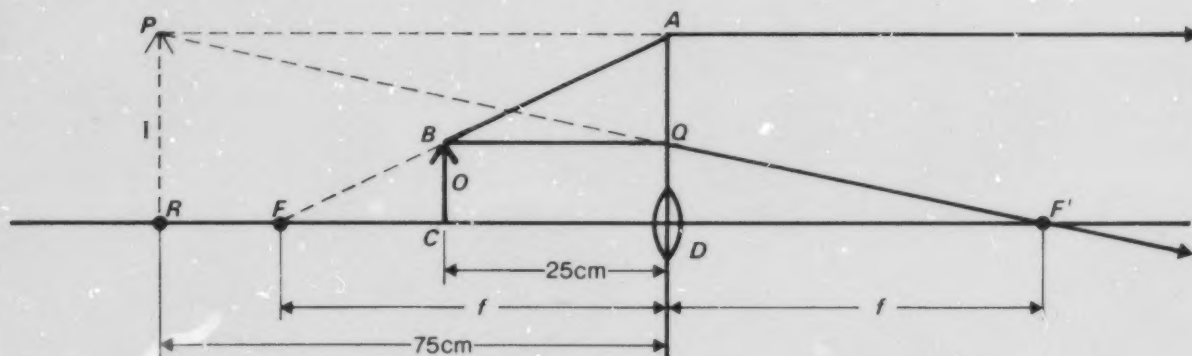
References:

Haber-Schaim, 4th ed., p. 9.
Ingram, Part 2, pp. 60, 61.
Williams, Sect. 14.4.

23 Correct Response: B

Discussion:

The following diagram shows the situation described.



I is the virtual image of the object O , and F and F' are the two foci of the lens. Also,

$CD = 25 \text{ cm}$

$$\overline{FD} = \overline{F'D} = f, \text{ where } f \text{ is the focal length}$$

and $\overline{RD} = 75$ cm

Now $\triangle AFD$ is similar to $\triangle BFC$

$$\frac{\overline{AD}}{\overline{BC}} = \frac{\overline{FD}}{\overline{FC}}$$

and since $\overline{AD} = \overline{PR}$,

$$\frac{\overline{PR}}{\overline{BC}} = \frac{f}{f - 25} \quad \dots (1)$$

Further, $\triangle PF'R$ is similar to $\triangle QF'D$

$$\frac{\overline{PR}}{\overline{QD}} = \frac{\overline{FR}}{\overline{FD}}$$

and since $\overline{QD} = \overline{BC}$

$$\frac{\overline{PR}}{\overline{BC}} = \frac{75 + f}{f} \quad \therefore (2)$$

Equating (1) and (2) gives

$$\begin{aligned} \frac{75+f}{f} &= \frac{f}{f-25} \\ \Rightarrow (75+f)(f-25) &= f^2 \\ \Rightarrow 75f - 25f - 1875 &= 0 \\ \Rightarrow 50f &= 1875 \\ \Rightarrow f &= 37.50 \text{ cm} \end{aligned}$$

References:

Haber-Schaim, 4th ed., pp. 64, 65.
Mayfield, Book HS7, p. 11.
Williams, Sect. 14.9.

24–26 Correct Responses: 24 D

25 E

26 C

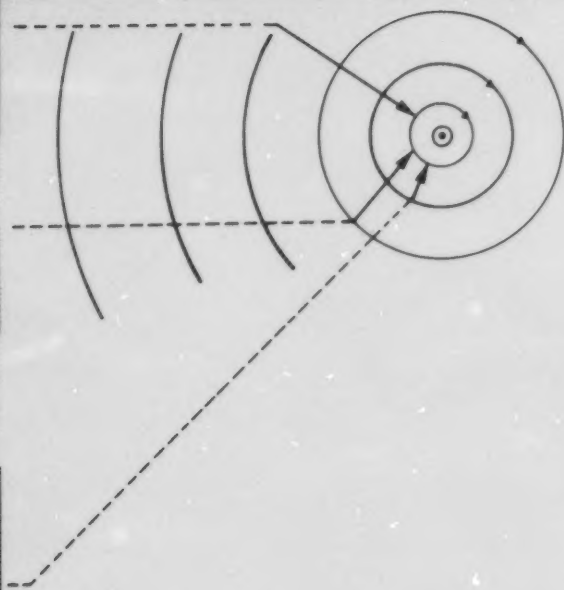
Discussion:

Because light rays do not pass through a mirror, A, B and C must be incorrect in items 24 and 25. The ray parallel to the principle axis converges in item 24, and hence D is correct, but diverges in item 25, and hence E is correct.

26 The pair of diverging reflections in this diagram can only result from a convex mirror (alternative C).

References:

Haber-Schaim, 4th ed., pp. 34-38, 64, 65.
Ingram, Part 2, pp. 54, 55, 62.
Mayfield, Book HS7, pp. 8, 11.
Williams, Sects. 13.9, 13.10, 14.9, 14.10.



Diagnostic Aid 12 Light — interference, diffraction and spectra

Description

This diagnostic aid is one of a collection of 21 diagnostic aids corresponding to the 21 separate tests in the *Physics Unit Tests*.

In each diagnostic aid an explanation is provided so that the reasons why the responses are correct or incorrect are available to you.

To gain maximum benefit from the *Physics Unit Tests* weaknesses diagnosed need to be followed up. These diagnostic aids make it possible for you to proceed with this follow up in your own time. If you do not understand the discussion you are advised to seek help from your teacher.

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- Ingram: Ingram, A.D., Kuhl, D.H., McCarthy, I.E., Sandercock, E.R., Smith, W.F., and Waite, P.J. *Physics: A Laboratory-oriented Approach*. (Study Guide Leaving Part 1, Study Guide Matriculation Part 2). Adelaide: Rigby, 1971, 1972.
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- Project Physics: *Project Physics Course: Programmed Instruction Books* (Kinetic Molecular Theory of Gases, Waves 1-2, Equations 1-3, Vectors 1-3); *Text and Handbook* (Units 1-6). Sydney: Martin Educational, 1970.
- Williams: Williams, J.E., Trinklei, F.E., Metcalfe, H.C., and Lefler, R.W. *Modern Physics*. New York: Holt, Rinehart, & Winston, 1976.

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Do not write on this booklet

1 Correct Response: C**Discussion:**

There are two main types of waves: transverse and longitudinal. Properties A, B and D are properties of waves in general, and could occur for either type of wave. However, polarization of light can only be explained by the property of transverse waves whereby the planes of vibration of two waves can be different. The plane of polarization is defined as the plane of vibration of the transverse wave. For all longitudinal waves, the direction of vibration is in the direction of propagation. Longitudinal waves cannot have different polarizations.

References:

Ingram, Part 2, pp. 47, 64.
Mayfield, Book 2, pp. 113, 114.
Project Physics, Unit 4, p. 21.
Williams, Sect. 15.6.

2 Correct Response: A**Discussion:**

The angle between successive pairs of fringes of a pattern from a diffraction grating is given by:

$$\sin \theta = \frac{\lambda}{d}$$

where d is the distance between the lines on the grating. (Note the similarity to the double slit relationship.) The wavelength and frequency of light are connected by the relationship:

$$c = \lambda f$$

Thus larger angles of diffraction are caused by an increased wavelength and hence a lower frequency. (Alternative A)

References:

Ingram, Part 2, p. 101.
Mayfield, Book 2, p. 107.
Project Physics, Unit 4, p. 13.
Williams, Sects. 15.3, 15.4.

3 and 4 Correct Responses: 3 B**4 A****Discussion:**

An interference pattern is caused by light from each slit travelling along different path lengths before interfering at the screen.

Now the path length MG and NG are the same. There is constructive interference at G, and hence a bright band occurs (alternative B, item 3).

The path lengths NK and MK are different by $\frac{\lambda}{2}$.

The rays are out of phase causing destructive interference at K (alternative A, item 4).

References:

Haber-Schaim, 4th ed., pp. 130, 148.
Ingram, Part 2, p. 88.
Mayfield, Book 2, pp. 98–101.
Project Physics, Unit 4, pp. 13, 14.
Williams, Sect. 15.1.

5 Correct Response: C**Discussion:**

When light travels through a medium of refractive index n , its frequency remains the same but its wavelength changes and is given by:

$$\lambda_{\text{medium}} = \frac{\lambda_o}{n}$$

$$\text{If } n = \frac{4}{3} \Rightarrow \lambda_{\text{medium}} = \frac{3}{4} \lambda_o$$

Now, the angle between successive dark bands is given by:

$$\sin \theta = \frac{\lambda}{d}$$

Thus the separation of the bands is proportional to the wavelength (λ). If λ is decreased to $\frac{3}{4}$ of its original value, the distance between bands is decreased by the same amount.

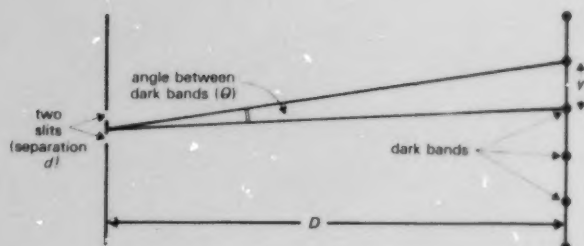
References:

Haber-Schaim, 4th ed., pp. 118, 134.
Ingram, Part 2, pp. 58, 88.
Mayfield, Book 2, pp. 93–96.
Project Physics, Unit 3, p. 130.
Williams, Sects. 14.2, 14.3.

6 Correct Response: D

Discussion:

To answer this question, it is best to refer to the diagram below which describes the situation.



The following relationships hold:

$$\sin \theta = \frac{\lambda}{d} \quad \dots (1)$$

and $\sin \theta = \frac{y}{D} \quad \dots (2)$

$$\Rightarrow \frac{y}{D} = \frac{\lambda}{d} \quad \dots (3)$$

Applying equation (3), if λ is decreased, then the separation between the dark bands (y) also decreases (alternative D). In both alternatives A and B, y is increased, while C leaves y unchanged.

References:

Haber-Schaim, 4th ed., p. 134.
Ingram, Part 2, p. 88.
Mayfield, Book 2, pp. 98-101.

7 Correct Response: B

Discussion:

This device causes each position, which was a bright band, to become a dark band and vice versa. The path difference which did cause destructive interference now causes constructive interference. The pattern is thus shifted by $\frac{y}{2}$.

References:

Haber-Schaim, 4th ed., p. 138.
Mayfield, Book 2, pp. 98-102.
Williams, Sect. 15.1.

8 Correct Response: D

Discussion:

Alternative D is the only satisfactory explanation of the central maximum being twice the width of other maxima. The two point source explanations, A and C, would predict all maxima with equal width. No interference pattern can result from a single point source.

References:

Haber-Schaim, 4th ed., p. 154.
Ingram, Part 2, p. 99.
Mayfield, Book 2, pp. 105, 106.
Project Physics, Unit 3, p. 124.
Williams, Sect. 15.5.

9 Correct Response: D

Discussion:

For a two slit interference pattern, the separation of the dark bands is proportional to the wavelength (see item 6).

From the pattern we see three red light band separations are equal to four blue light band separations,

that is,

$$3\lambda_{\text{red}} = 4\lambda_{\text{blue}}$$

$$\frac{\lambda_{\text{red}}}{\lambda_{\text{blue}}} = \frac{4}{3}$$

References:

Haber-Schaim, 4th ed., p. 151.
Ingram, Part 2, p. 88.
Mayfield, Book 2, p. 100.
Project Physics, Unit 3, p. 120.
Williams, Sect. 15.1.

10-13 Correct Responses: 10 F

11 D

12 B

13 C

Discussion:

The interference pattern is primarily determined by the double slit interference. D is much larger than d , and hence a double slit interference pattern can occur inside the width of the single-slit central bright fringe. (See diagram, item 18.)

- 10 The double slit separation (D) is doubled. The separation of the dark bands, which is inversely proportional to D , is therefore halved. (Alternative F.)

- 11 The width of the slits only effects the single slit interference pattern. The dominant double slit pattern being observed is unaltered. (Alternative D.)

- 12 The separation of the bands is proportional to the distance to the screen (see item 6). Thus alternative B is the correct response.

To calculate the solution to item 13, use the equation given in item 6. Remember to convert all lengths to metres. Using the notation given in the diagram, one finds:

$$\frac{y}{x} = \frac{\lambda}{D},$$

where y is the width of bands

$$\lambda = \text{wavelength} = 7 \times 10^{-7} \text{ m}$$

$$x = 2 \text{ m}$$

$$D = 1 \times 10^{-4} \text{ m}$$

giving

$$y = 1.4 \times 10^{-2}$$

(Alternative C)

References:

Haber-Schaim, 4th ed., p. 158.

Ingram, Part 2, p. 100.

Mayfield, Book 2, pp. 98-101.

Project Physics, Unit 3, p. 120; Unit 4, p. 13.

Williams, Sect. 15.1.

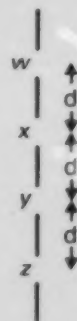
14 Correct Response: C

Discussion:

In this extremely complicated situation of four narrow slits producing an interference pattern, there are several effects going on at once. It makes the analysis of the situation much easier if it is considered that the four slits act as a combination of pairs of slits. It is known that for a pair of slits of width D , there are nodes when:

$$\sin \theta = \frac{\lambda}{2D}, \frac{3\lambda}{2D}, \frac{5\lambda}{2D}, \dots$$

Consider the diagram below. The pairs of slits that are possible where w is one, are: wx , wy and wz . The separation of these pairs of slits are d , $2d$ and $3d$ respectively.



Now one could in turn consider all the other possible pairs of slits, but it would still be found that there are only combinations of width d , $2d$ or $3d$.

To find the nodes of the four-slit arrangement, one only needs to list the nodes of each of the two slit combinations. So when,

$$D = d \text{ Nodes occur when } \sin \theta = \frac{\lambda}{2d}, \frac{3\lambda}{2d}, \dots$$

$$D = 2d \text{ Nodes occur when } \sin \theta = \frac{\lambda}{4d}, \frac{3\lambda}{4d}, \frac{5\lambda}{4d}, \dots$$

$$D = 3d \text{ Nodes occur when } \sin \theta = \frac{\lambda}{6d}, \frac{\lambda}{2d}, \frac{5\lambda}{6d}, \dots$$

Alternative C satisfies these conditions.

References:

Haber-Schaim, 4th ed., p. 134.

Ingram, Part 2, p. 88.

Mayfield, Book 2, pp. 100, 109.

Project Physics, Unit 3, p. 120.

15-17 Correct Responses: 15 C

16 B

17 A

Discussion:

Constructive interference occurs when the optical path difference is $0, \lambda, 2\lambda, \dots$. The central maximum corresponds to the zero path length difference (alternative A, item 17). Both Q and U are the next bright fringes. They result from one wavelength pathlength difference (item 15).

Destructive interference occurs when the optical path differences are $\frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}, \dots$. The first minima

(R and T) corresponds to $\frac{\lambda}{2}$ path differences. The second minima (P and V) corresponds to path differences of $\frac{3\lambda}{2}$ (item 16).

References:

Haber-Schaim, 4th ed., p. 130.

Ingram, Part 2, p. 88.

Mayfield, Book 2, pp. 98-101.

Project Physics, Unit 3, p. 120.

Williams, Sect. 15.1.

18-20 Correct Responses: 18 B

19 D

20 A

Discussion:

These questions refer to a situation already discussed in items 10-13. Laser light shows the same interference effects as any other light. The diffraction envelope is due to single slit interference in each slit and the interference pattern is due to the two-slit interference. In both interference patterns the angular spread is proportional to the wavelength (refer to item 6). Thus a reduced wavelength causes both patterns to become narrower (item 18). The angular spread is inversely proportional to the separation of the slits and the width of each slit.

In item 19, increasing the slit width effects only the diffraction envelope and makes this narrower. The angular spread is unaltered in item 20, but increasing the distance to the screen magnifies the whole pattern. (Alternative A.)

References:

Haber-Schaim, 4th ed., p. 158.

Ingram, Part 2, p. 100.

Mayfield, Book 2, pp. 98-101, 105, 106.

Project Physics, Unit 3, p. 120; Unit 4, p. 13.

Williams, Sect. 15.1, 15.5.

21 Correct Response: B

Discussion:

A thin film produces an interference pattern when light reflected from the top surface interferes with light reflected from the bottom surface of the film. The nature of the interference is determined by the optical path difference between each of the reflected light rays. The path difference is twice the width of the air gap. (Note this means the refractive index of the glass is irrelevant.)

There is another node each time the path length is increased by λ , and hence the air gap is increased by $\frac{\lambda}{2}$.

$$\begin{aligned}\text{Thus the thickness of the material} &= 100 \times \frac{\lambda}{2} \\ &= 50\lambda \\ &= 3.0 \times 10^4 \text{ nm}\end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 161.

Ingram, Part 2, p. 92.

Mayfield, Book 2, pp. 102, 103.

Williams, Sect. 15.2

22 Correct Response: B

Discussion:

The first point to note is that the phase change upon reflection from both interfaces is the same. At both interfaces the refractive index increases. Thus the first minimum in intensity corresponds to a path difference of $\frac{\lambda}{2}$, that is, a film thickness of $\frac{\lambda}{4}$.

The wavelength of light in the oil film

$$\lambda_{\text{oil}} = \frac{\lambda}{n_{\text{oil}}}$$

$$\Rightarrow \lambda_{\text{oil}} = 500 \text{ nm}$$

Hence the least thickness of oil for a minimum is 125 nm.

References:

Haber-Schaim, 4th ed., p. 161.

Ingram, Part 2, p. 92.

Mayfield, Book 2, pp. 102, 103.

Williams, Sect. 15.2.

23 Correct Response: C

Discussion:

Thin film interference is determined by the ratio $\frac{\lambda}{d}$, where d is the additional optical pathlength of the ray which reflects off the bottom surface of the film. This length depends on the angle of incidence of the light.



Colours correspond to different wavelengths of light. Thus if one wavelength is constructively interfering while another is destructively interfering for a particular d , the colour separation occurs. The colours seen depend on the angle of incidence because of its effect on d .

References:

Mayfield, Book 2, pp. 102–104.
Williams, Sect. 15.2.

24 Correct Response: A

Discussion:

The angle of the first order is proportional to λ , and inversely proportional to the separation of the grating lines. The grating line separation is $\frac{x}{n}$

$$\rightarrow \sin \theta = \frac{\lambda}{\frac{x}{n}}$$

$$\rightarrow \sin \theta = \frac{n\lambda}{x}$$

References:

Ingram, Part 2, p. 101.
Mayfield, Book 2, pp. 107–109.
Williams, Sect. 15.4.

25 and 26 Correct Responses: 25 C

26 A

Discussion:

A line spectrum has only some particular wavelengths present. This contrasts with a continuous spectrum where all wavelengths of the spectrum are present in equal intensities.

The difference in the spectrum of light sources is due to the different ways light is produced. If single atoms are excited and then emit light, that light will be at special wavelengths characteristic of the atom. This is a line spectrum. Single atoms are found in gases or vapours. A mercury vapour lamp, a hydrogen discharge tube, even burning some elements, are all single atom type sources (alternative C, item 25).

However, if a solid is heated to emit light (e.g. a metal like tungsten) then the light comes from atoms whose properties are altered by the many atoms surrounding it. This combined atom effect means that when they emit light, there is a mixture of wavelengths, not just special values. A continuous spectrum can be observed. In item 26, R is excluded because the green plastic absorbs some of the spectrum and transmits only a small part, the green wavelengths. The spectrum is no longer continuous.

References:

Haber-Schaim, 4th ed., p. 587.
Ingram, Part 2, pp. 113, 149.
Mayfield, Book 2, p. 140–144.
Project Physics, Unit 5, p. 62.

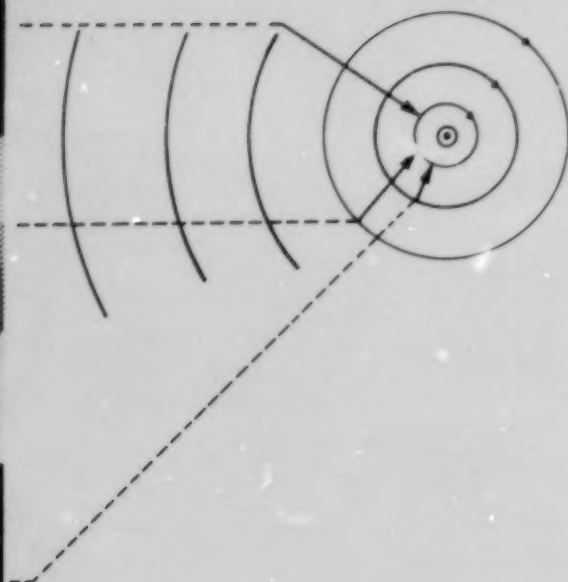
27 Correct Response: D

Discussion:

Following the discussion in items 25 and 26, Fraunhofer lines occur when single atoms absorb light. The wavelengths absorbed are particular values only. A line spectrum is hence observed. The wavelength absorbed by single atoms in a gas are exactly those emitted when the same element is used as a light source as in items 25 and 26.

References:

Haber-Schaim, 4th ed., p. 601.
Ingram, Part 2, p. 149.
Mayfield, Book 2, pp. 140–144.
Project Physics, Unit 5, p. 62.



Diagnostic Aid 13 Models of light

Description

This diagnostic aid is one of a collection of 21 diagnostic aids corresponding to the 21 separate tests in the *Physics Unit Tests*.

In each diagnostic aid an explanation is provided so that the reasons why the responses are correct or incorrect are available to you.

To gain maximum benefit from the *Physics Unit Tests* weaknesses diagnosed need to be followed up. These diagnostic aids make it possible for you to proceed with this follow up in your own time. If you do not understand the discussion you are advised to seek help from your teacher.

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Models of light

1 Correct Response: A

Discussion:

When light moves from one medium to another, its frequency is not changed. However, the speed and direction of the light does alter. The change in speed alters the wavelength through the relationship, $v = f\lambda$. Light travels slower in the medium with a higher refractive index.

References:

Haber-Schaim, 4th ed., p. 116.
Ingram, Part 2, p. 58.
Mayfield, Book 2, p. 96.
Project Physics, Unit 3, p. 130.
Williams, Sect. 14.1, 14.2.

2 Correct Response: B

Discussion:

The speed of light in a medium of refractive index n is given by: $v = \frac{c}{n}$, where c is the speed of light in air. Hence, in this question,

$$\begin{aligned} v_{\text{glass}} &= \frac{3.0 \times 10^8}{1.5} \\ &= 2.0 \times 10^8 \text{ m s}^{-1} \end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 116.
Ingram, Part 2, p. 58.
Mayfield, Book 2, p. 96.
Williams, Sect. 14.2.

3 Correct Response: D

Discussion:

Upon reflection, the leading edge of the pulse must remain the leading edge. Hence A and C are rejected. Experimentally one finds an inversion of the pulse upon reflection from a fixed end, hence alternative D is correct.

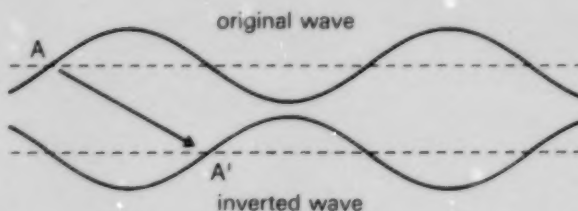
References:

Haber-Schaim, 4th ed., p. 98.
Ingram, Part 2, p. 77.
Mayfield, Book 2, p. 74.
Project Physics, Unit 3, p. 109.
Williams, Sect. 10.10.

4 Correct Response: C

Discussion:

There are many ways of expressing phase. Consider a sinusoidal wave train that has been inverted, as shown in the diagram.



The inverted wave looks exactly as if the original pulse has been shifted half a wavelength $\left(\frac{\lambda}{2}\right)$.

For example, the point A moves to A'. This shift is called a phase change of $\frac{1}{2}$.

Note: It can also be called a shift of π , that is, half of a full cycle which is 2π , or a shift of 180° , that is half of a full circle of 360° .

References:

Haber-Schaim, 4th ed., p. 138.
Ingram, Part 2, p. 77.
Mayfield, Book 2, p. 102.
Project Physics, Unit 3, p. 12.
Williams, Sect. 10.6.

5 Correct Response: B

Discussion:

The question does not ask for the angle of refraction. It asks for the angle between the interface and the ray in medium 2. Hence, B is correct.

References:

Mayfield, Book 2, pp. 92, 93.

6 Correct Response: D**Discussion:**

The wave model predicts the velocity of light (v) in a medium of refractive index n to be given by

$$v = \frac{c}{n}$$

The relative refractive index can be calculated using Snell's Law:

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$$

The relative speeds of light

$$\frac{v_2}{v_1} = \frac{c/n_2}{c/n_1}$$

$$= \frac{n_1}{n_2}$$

$$\text{therefore, } \frac{v_2}{v_1} = \frac{\sin r}{\sin i}$$

$$\begin{aligned} \frac{v_2}{v_1} (\text{wave model}) &= \frac{\sin 60^\circ}{\sin 37^\circ} \\ &= \frac{3}{2} \end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 116.
Ingram, Part 2, p. 58.
Mayfield, Book 2, p. 95.
Project Physics, Unit 4, p. 11.
Williams, Sect. 14.3.

7 Correct Response: A**Discussion:**

The particle model predicts the velocity of light in a medium to be: $v = cn$

Following the calculation in item 6.

$$\begin{aligned} \frac{v_2}{v_1} (\text{particle model}) &= \frac{n_2}{n_1} \\ &= \frac{\sin i}{\sin r} \end{aligned}$$

$$\Rightarrow \frac{v_2}{v_1} (\text{particle model}) = \frac{2}{3}$$

Using this, and the solution to item 6, gives

$$\begin{aligned} \frac{v_2}{v_1} (\text{particle model}) &= \frac{2}{3} \\ \frac{v_2}{v_1} (\text{wave model}) &= \frac{3}{2} \\ &= \frac{4}{9} \end{aligned}$$

Note: Experimentally the wave model is found to give the correct prediction.

References:

Haber-Schaim, 4th ed., p. 80.
Mayfield, Book 2, pp. 94, 95.

8 and 9 Correct Responses: 8 B

9 A

Discussion:

The leading edge of the pulse must remain the leading edge of the pulse. This excludes 1. The reflected pulse cannot be more energetic than the incident pulse. As all the pulses are in the same string the energy of a pulse is only related to the amplitude. This means the height of the reflected pulses cannot be greater than the incident pulses height. Nor can the length of the pulse alter. Thus IV and V are excluded. Both II and III remain possible reflections. (Alternative B, item 8.)

The reflected pulse from a light to heavy interface inverts the pulse (II). The reflected pulse from a heavy-to-light-medium interface is the same way up (III).

Item 9 requires a light to heavy interface first, then a heavy to light interface. Only A satisfies this criteria.

References:

Haber-Schaim, 4th ed., p. 98.
Ingram, Part 2, p. 77.
Mayfield, Book 2, pp. 74, 75.
Project Physics, Unit 3, p. 127.
Williams, Sect. 10.10.

10 Correct Response: D**Discussion:**

By treating the interface as a ramp potential, the particle model does explain Snell's law (and hence A and B). But in order to do so, it predicts light travels faster in a dense medium than in air. Experiments have shown the converse is true. Thus the failing of the particle model is that it does not predict the observation that light travels faster in air than in a dense medium like water.

References:

Haber-Schaim, 4th ed., p. 98.
Mayfield, Book 2, pp. 94, 95.
Project Physics, Unit 4, pp. 11, 12.
Williams, Sect. 12.2.

11 Correct Response: C**Discussion:**

A wave pulse is observed to reflect off a barrier with angles of incidence and reflection equal. A hard particle (like a steel ball) also reflects off a surface with equal angles of incidence and reflection. Thus the laws of reflection are explained by both models.

References:

Haber-Schaim, 4th ed., pp. 78, 110.
Ingram, Part 2, p. 54.
Mayfield, Book 2, pp. 92, 93.
Project Physics, Unit 4, p. 11.
Williams, Sect. 12.2, 12.3.

12 Correct Response: B**Discussion:**

Diffraction is explained by interference between waves. An interference which produces a cancellation cannot occur with the particle model. Thus only the wave model is successful in explaining diffraction.

References:

Haber-Schaim, 4th ed., p. 128.
Ingram, Part 2, p. 48.
Mayfield, Book 2, p. 104.
Project Physics, Unit 4, p. 13.
Williams, Sect. 12.3.

13 Correct Response: A**Discussion:**

Newton attempted to explain A using the particle model by assuming some areas of a surface are perfect reflectors and some areas are perfect absorbers. The reflection needs to be perfect because if energy is lost then the speed of light would change, and this is not observed. This explanation is not satisfactory because no evidence of these different types of areas on a surface has ever been seen, even under the most powerful microscope.

Alternative B can be explained if one assumes the intensity of light is just the number of particles hitting a certain area. The inverse square relationship holds as long as the particles move in straight lines.

Heat is just another form of energy. Particles which move have kinetic energy. When the particles collide with a surface this kinetic energy is transferred to heat energy, hence C is explained.

Particles have momentum. Whenever momentum changes there is a corresponding impulse.

$$\begin{aligned}\text{Impulse} &= \text{change in momentum} \\ &= \text{force} \times \text{time applied}\end{aligned}$$

Pressure results from the impulse that occurs when a particle is reflected off a surface. Hence D also is explained.

References:

Haber-Schaim, 4th ed., p. 74.
Williams, Sect. 10.11.

14-16 Correct Responses: 14 B**15 C****16 C****Discussion:**

From item 6, the relative speeds of light in two media are:

$$\frac{v_2}{v_1} = \frac{n_1}{n_2}$$

The frequency of light does not alter when waves pass through an interface. Thus applying the relation $v = \lambda f$ to the equation above, one finds:

$$\begin{aligned}\frac{v_2}{v_1} &= \frac{\lambda_2}{\lambda_1} \\ &= \frac{n_1}{n_2}\end{aligned}$$

Item 14 asks for the ratio

$$\begin{aligned}\frac{n_2}{n_1} &= \frac{\lambda_1}{\lambda_2} \\ &= \frac{6}{4}\end{aligned}$$

The frequency (item 15) is found using $v = \lambda f$, where

$$v = 60 \text{ cm s}^{-1}$$

$$\lambda = 6 \text{ cm}$$

$$\Rightarrow f = 10 \text{ s}^{-1}$$

16 The velocity in medium 2 can be calculated using:

$$\begin{aligned}\frac{v_2}{v_1} &= \frac{\lambda_2}{\lambda_1} \\ v_2 &= \frac{4}{6} \times 60 \\ &= 40 \text{ cm s}^{-1}\end{aligned}$$

References:

Haber-Schaim, 4th ed., p. 116.
Ingram, Part 2, p. 58.
Mayfield, Book 2, pp. 77, 88, 89.
Project Physics, Unit 3, pp. 130, 131.
Williams, Sect. 14.2, 14.3.

17 Correct Response: A**Discussion:**

X is a node. The displacement of the upright pulse will always be equal and opposite to the displacement of the upside down pulse as the pulses pass through X. Applying the superposition principle, the net displacement from these two contributions will thus be zero.

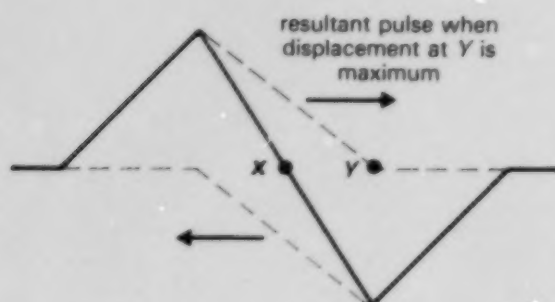
References:

Haber-Schaim, 4th ed., p. 92.
Ingram, Part 2, p. 48.
Mayfield, Book 2, pp. 75, 76.
Project Physics, Unit 3, p. 113.
Williams, Sect. 10.14.

18 Correct Response: C

Discussion:

The maximum downward displacement will occur when the front of the upright pulse just arrives at Y. At this instant the peak of the downward pulse is at position X, so the displacement is 4 cm (see diagram).



References:

Haber-Schaim, 4th ed., p. 92.
Ingram, Part 2, p. 48.
Mayfield, Book 2, pp. 75, 76.
Project Physics, Unit 3, p. 113.
Williams, Sect. 10.14.

19 Correct Response: D

Discussion:

For a string of length L with fixed ends, a standing wave pattern is produced for wavelengths:

$$\lambda = \frac{2L}{n}$$

where n is any integer.

The corresponding frequencies are:

$$f = \frac{v}{\lambda} = \frac{vn}{2L}$$

Thus there are many particular values of frequency which give standing wave patterns, and not just one or two.

References:

Ingram, Part 2, pp. 77-85.
Mayfield, Book 2, pp. 81, 82.
Project Physics, Unit 3, p. 122.
Williams, Sect. 10.16.

20-22 Correct Responses: 20 D

21 B

22 C

Discussion:

A straight line, when reflected by a parabolic reflector, first converges upon the focus with semi-circular pulses, then spreads out from the focus in semi-circular pulses.

At $t = 4s$ (item 20) the centre of the pulse has moved 80 cm. This means it has 20 cm (one grid spacing) to travel before it reaches the focus. The pulse will be a semicircle, centred at the focus, of radius 20 cm (alternative D).

At $t = 5s$ (item 21) the centre, and thus all of the pulse will be at the focus (alternative B).

At $t = 6s$ (item 22) the pulse is again a semicircle, centred on the focus, of radius 20 cm and moving outward and to the left (alternative C).

References:

Haber-Schaim, 4th ed., pp. 28, 108.
Ingram, Part 2, p. 55.
Mayfield, Book 2, pp. 85-88.
Project Physics, Unit 3, p. 127.
Williams, Sect. 13.8.

23 Correct Response: C

Discussion:

When a ball is reflected, the angle of reflection is equal to the angle of incidence. Path III is the only path which has this property. Paths I and IV are not reflections as the ball does not come back into the area it came from. The balls remain in the interface.

References:

Mayfield, Book 2, p. 92.
Williams, Sect. 12.2.

24 Correct Response: A

Discussion:

If the incline surface $MNPQ$ is steeper, this means the ball will fall down the slope faster. The path v_2 will then be closer to being perpendicular to the interface. In terms of Snell's law:

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$$

A steeper incline means the angle of refraction is reduced for the same angle of incidence. Thus the relative refractive index will be increased.

References:

Haber-Schaim, 4th ed., p. 80.

Mayfield, Book 2, p. 94.

Williams, Sect. 12.2.

25 Correct Response: D

Discussion:

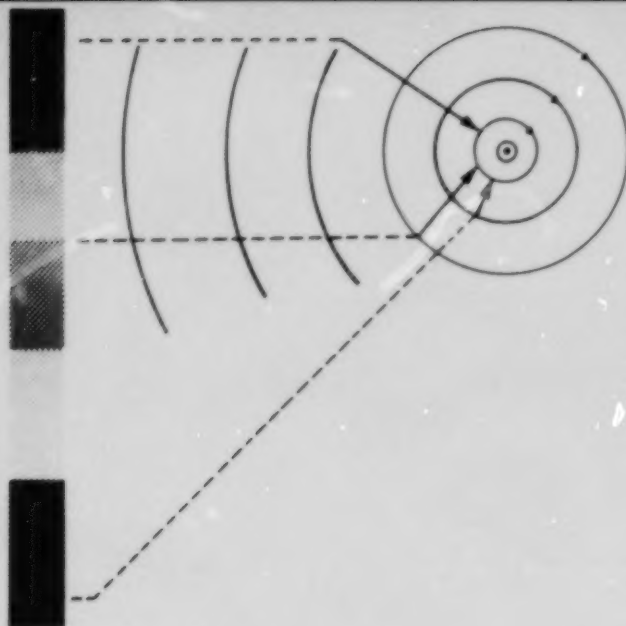
At the air-water interface, light does not appear curved. The region where it bends is not seen. In this model the ball changes direction throughout the incline $NMQP$. This whole region must then correspond to the air-water interface.

References:

Haber-Schaim, 4th ed., p. 80.

Mayfield, Book 2, pp. 94, 95.

Williams, Sect. 12.2.



Diagnostic Aid 14 Kinetic theory of gases

Description

This diagnostic aid is one of a collection of 21 diagnostic aids corresponding to the 21 separate tests in the *Physics Unit Tests*.

In each diagnostic aid an explanation is provided so that the reasons why the responses are correct or incorrect are available to you.

To gain maximum benefit from the *Physics Unit Tests* weaknesses diagnosed need to be followed up. These diagnostic aids make it possible for you to proceed with this follow up in your own time. If you do not understand the discussion you are advised to seek help from your teacher.

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1 Correct Response: C**Discussion:**

The temperature of a gas is a measure of the average kinetic energy of translation of the molecules. Here the temperature is 'maintained at a fixed value' so that the average kinetic energy of the molecules will not have altered and, hence,

$$\frac{\text{Final kinetic energy}}{\text{Initial kinetic energy}} = \frac{1}{1}$$

References:

Haber-Schaim, 3rd ed., p. 380; 4th ed., pp. 381, 382.
Ingram, Part 2, p. 36.
Mayfield, Book 2, p. 42.
Project Physics, Unit 3, p. 86.
Williams, Sect. 8.2.

2 Correct Response: B**Discussion:**

The gas relation $PV = NkT$ may be used, where P is the pressure, V is the volume, N is the number of molecules, k is the Boltzmann constant and T is the absolute temperature in degrees Kelvin ($^{\circ}\text{K}$).

Now, $V = Nk \frac{T}{P}$ and since N is constant,

$$V \propto \frac{T}{P}$$

$$\therefore \frac{V_2}{V_1} = \frac{T_2}{T_1} \times \frac{P_1}{P_2}$$

In this example, $V_1 = 3$ litres, $P_2 = 2P_1$, and $T_2 = \frac{4}{3}T_1$.

$$\text{so } \frac{V_2}{3} = \frac{4}{3} \times \frac{1}{2}$$

$$\text{giving, } V_2 = 3 \times \frac{4}{3} \times \frac{1}{2}$$

$$\text{that is, } V_2 = 2 \text{ litres.}$$

References:

Haber-Schaim, 3rd and 4th ed., p. 376.
Ingram, Part 2, pp. 29, 30.
Mayfield, Book 2, pp. 34, 42.
Project Physics, Unit 3, p. 83.
Williams, Sect. 8.13.

3 Correct Response: A**Discussion:**

As in item 2, the relation $PV = NkT$ can be used and again N is constant.

$$\text{Thus, } \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\text{or } V \propto \frac{T}{P}$$

$$\therefore V_2 = V_1 \times \frac{P_1}{P_2} \times \frac{T_2}{T_1}$$

$$\text{Here, } V_1 = 0.25 \text{ L,}$$

$$P_1 = 9 \times 10^4 \text{ Nm}^{-2},$$

$$P_2 = 1 \times 10^5 \text{ Nm}^{-2}$$

$$T_1 = (27 + 273)^{\circ}\text{K} = 300^{\circ}\text{K,}$$

$$\text{and } T_2 = (-3 + 273)^{\circ}\text{K} = 270^{\circ}\text{K.}$$

$$\text{Hence, } V_2 = 0.25 \times \frac{9 \times 10^4}{1 \times 10^5} \times \frac{270}{300}$$

$$= 0.25 \times \frac{9}{10} \times \frac{9}{10}$$

$$= 0.20 \text{ L}$$

References:

Haber-Schaim, 3rd and 4th ed., p. 376.
Ingram, Part 2, pp. 29, 30.
Mayfield, Book 2, pp. 34, 42.
Project Physics, Unit 3, pp. 82, 83.
Williams, Sect. 8.13.

4 Correct Response: B**Discussion:**

Because each container, X and Y, hold 'the same mass of the same gas', then they will have the same number of molecules, N . This is true even though the volume and temperature are different as these will be in proportion, since

$$PV = NkT$$

$$\text{giving } N = \frac{PV}{kT}, \text{ with } P \text{ constant.}$$

The mass of the gas depends only on the number of molecules, and not on the temperature, thus the number of molecules is the same in both containers, X and Y. (Alternative B).

References:

Haber-Schaim, 3 & 4 ed., p. 376.
Ingram, Part 2, pp. 29-31.
Mayfield, Book 2, p. 42.
Project Physics, Unit 3, pp. 86, 87.
Williams, Sect. 8.2.

5 Correct Responses: B

Discussion:

The kinetic molecular model of a gas considers molecules which are widely separated but in continual random motion. Thus alternative B is not a basic assumption as it states that molecules move along pre-determined paths.

The other alternatives are consistent with the model which involves small widely spaced molecules in continual fast random motion and so colliding elastically with other molecules and the walls of the container. Intermolecular forces must be negligible if the collisions are to be elastic. The model's predictions are in agreement with the known behaviour of gases. (Alternative B).

References:

Haber-Schaim, 3rd ed., p. 377-380;
4th ed., p. 380.
Ingram, Part 2, p. 31.
Mayfield, Book 2, p. 36.
Project Physics, Unit 3, pp. 73-76.
Williams, Sect. 7.1, 7.19.

6-10 Correct Responses: 6 C

7 D

8 D

9 D

10 A

Discussion:

- 6 The ball must travel two lengths or 10 m between the hits at end X. It is travelling at 30 m s^{-1} and so will make three collisions with end X per second. (Alternative C).

- 7 The change in momentum, Δp , is given by the expression $m\Delta v$,

where m = mass of the particle,
and Δv = the change in velocity.

Since there is no energy loss when the ball collides with the wall of the box, the magnitude of the velocity of the ball after rebounding is still 30 m s^{-1} . Therefore, for each collision with end X and the subsequent rebounding in the opposite direction,

$$\begin{aligned}\Delta v &= \text{final velocity} - \text{initial velocity} \\ &= 30 - (-30) \\ &= 60 \text{ m s}^{-1}\end{aligned}$$

and hence $\Delta p = m\Delta v$

$$\begin{aligned}&= 0.2 \times 60 \\ &= 12 \text{ kg m s}^{-1}\end{aligned}$$

There are three such collisions per second, so the change in momentum per second is $3 \times 12 = 36 \text{ kg m s}^{-1}$. (Alternative D).

- 8 The average force exerted by the ball on end X is the change in momentum per second, that is

$$\begin{aligned}F \Delta t &= m\Delta v \\ \Rightarrow F &= \frac{m\Delta v}{\Delta t}\end{aligned}$$

Now from item 7,

$$m\Delta v \text{ per second} = 36$$

$$F = 36 \text{ N}$$

Alternatives A, B and C are consequential answers from item 7.

- 9 One hundred such collisions will mean one hundred times the average force for one such collision. This was 36 N (see item 8) so the average force on end X is 3600 N.

Alternatives A, B and C are consequential answers from items 7 and 8.

- 10 The pressure on end X of 100 such balls is the force (see item 9) per unit area.

$$\begin{aligned}P &= \frac{F}{A} \\ &= \frac{3600}{(3 \times 4)} \\ &= 300 \text{ Pa}\end{aligned}$$

Again, alternatives B, C and D are consequential answers from the previous items.

References:

Haber-Schaim, 3rd ed., pp. 377, 378;
4th ed., pp. 377-379.
Ingram, Part 2, pp. 31-34.
Mayfield, Book 2, pp. 38-41.
Project Physics, Unit 3, pp. 84, 85.
Williams, Sect. 7.1.

11 Correct Response: C**Discussion:**

Unless the molecules of a real gas are widely spaced, they will not follow the predicted behaviour of an ideal gas.

That this is true can be shown convincingly by variations of pressure. As the pressure of a gas increases, the gas behaviour departs from that expected by the gas model, because the molecules are closer together. (Alternative C).

Alternatives A and D are important, but since they remain unchanged when the molecules are not widely spaced, they are not influential to the predicted behaviour of the gas.

Alternative B is inconsistent with an elastic collision which is important to the gas model.

References:

Haber-Schaim, 3rd ed., pp. 377, 378;
4th ed., pp. 377-379.
Ingram, Part 2, pp. 29-31, 38.
Mayfield, Book 2, pp. 37, 47-49.
Project Physics, Unit 3, pp. 71-74.
Williams, Sect. 7.19.

- 12-14 Correct Responses: 12 B**
13 C
14 B

Discussion:

- 12** The pressure and number of molecules is constant, thus $PV = NkT$ becomes

$V \propto T$, which is Charles' law.

$$\text{Thus } \frac{V_2}{V_1} = \frac{T_2}{T_1}$$

Now, $V_1 = 0.50$ litre, $T_1 = 293^\circ\text{K}$, $T_2 = 273^\circ\text{K}$ and $V_2 =$ volume of gas at 0°C .

$$\text{Therefore, } V_2 = \frac{273}{293} \times 0.50 = 0.47 \text{ litre}$$

- 13** Since the volume (as in item 12) is proportional to the absolute temperature, then

$$\frac{V_2}{V_1} = \frac{T_2}{T_1}$$

Now, $V_1 = 0.50$ litre, $T_1 = 293^\circ\text{K}$, $T_2 = 473^\circ\text{K}$ and $V_2 =$ volume of gas at 200°C .

$$V_2 = \frac{473}{293} \times 0.50$$

$$V_2 = 0.81 \text{ litre}$$

- 14** Again the same relationship is applied

$$\frac{V_2}{V_1} = \frac{T_2}{T_1}$$

where $V_1 = 0.50$ litre, $T_1 = 293^\circ\text{K}$, $V_2 = 0.25$ litre and $T_2 =$ temperature for 0.25 litre of gas

$$\text{So } T_2 = \frac{0.25}{0.50} \times 293$$

$$= 146.5^\circ\text{K}$$

The temperature is $146.5 - 273$, that is
 -126.5°C (alternative B)

References:

Haber-Schaim, 3rd ed., p. 376;
4th ed., pp. 376, 377.
Ingram, Part 2, pp. 29, 30.
Mayfield, Book 2, pp. 34, 42.
Project Physics, Unit 3, pp. 82, 83.
Williams, Sect. 8.11.

15 Correct Response: C**Discussion:**

For pressures of less than two atmospheres the relationship between P and $\frac{1}{V}$ is a good approximation of a linear one. Whether a conclusion can be made depends on the available data. Here we have only one set of information (one set of results) and so it is unwise to form such a conclusion, as in alternative A, on this set alone. Thus alternative C is a wise check on these results, as they need verifying or correcting.

Any other graphs, as alternatives B and D suggest, would not produce productive results as we have already a relationship which needs further verification or revision.

References:

Haber-Schaim, 3rd & 4th ed., pp. 374, 375.
Ingram, Part 2, p. 27.
Mayfield, Book 2, p. 32.
Project Physics, Unit 3, p. 82.
Williams, Sect. 8.12.

16-18 Correct Responses: 16 D

17 C

18 A

Discussion:

- 16 In this item, T and N are constant, thus the relation

$PV = NkT$ can be expressed as $P \propto \frac{1}{V}$

Hence, $\frac{P_2}{P_1} = \frac{V_1}{V_2}$

Now $P_1 = 1$ atmosphere, $V_1 = 10A \text{ cm}^3$,
 $V_2 = (10-8)A = 2A \text{ cm}^3$ (A is the area of cross section of the tube).

$$\begin{aligned}\text{so, } P_2 &= \frac{V_1}{V_2} \times P_1 \\ &= \frac{10}{2} \times 1 \\ &= 5 \text{ atmospheres.}\end{aligned}$$

That is, the pressure on the trapped air is 5 atmospheres.

- 17 Here V and N remain constant, thus $PV = NkT$ can be expressed as $P \propto T$,

$$\text{or, } \frac{P_2}{P_1} = \frac{T_2}{T_1}$$

Now since, $P_1 = 1$ atmosphere, $T_1 = 300^\circ\text{K}$,
 $T_2 = 400^\circ\text{K}$

$$\begin{aligned}\text{then } P_2 &= \frac{T_2}{T_1} \times P_1 \\ &= \frac{400}{300} \times 1 \\ &= \frac{4}{3}\end{aligned}$$

That is, the pressure on the trapped air would be $\frac{4}{3}$ atmospheres.

- 18 In this question only N remains constant and so

$PV = NkT$ can be written as $P \propto \frac{T}{V}$

$$\text{This gives } P_2 = \frac{T_2}{T_1} \cdot \frac{V_1}{V_2} \cdot P_1$$

Here, $T_1 = 300^\circ\text{K}$, $T_2 = 200^\circ\text{K}$, $V_1 = 10A \text{ cm}^3$,
 $V_2 = 3A \text{ cm}^3$ and $P_1 = 1$ atmosphere.

$$\begin{aligned}\text{Substituting, } P_2 &= \frac{200}{300} \times \frac{10A}{3A} \times 1 \\ &= 1 \times \frac{2}{3} \times \frac{10}{3} \text{ atmospheres}\end{aligned}$$

Hence, the pressure of the trapped air in atmospheres is $1 \times \frac{2}{3} \times \frac{10}{3}$.

References:

Haber-Schaim, 3rd & 4th ed., p. 376.
Ingram, Part 2, pp. 27-30.
Mayfield, Book 2, pp. 34, 42.
Project Physics, Unit 3, pp. 82, 83.
Williams, p. 191.

- 19 Correct Response: B

Discussion:

If two different gases are at the same temperature, T , then the molecules of the two gases will be moving with the same average kinetic energy, E_k . It is the kinetic energy of the molecules that determines the temperature of a gas, that is, $T \propto E_k$.

Alternatives A and C express quantities which are important to the kinetic energy but they are not directly related to the temperature. Similarly, the number of particles in each sample of gas bears no relation to the temperature, so D is incorrect.

References:

Haber-Schaim, 3rd ed., pp. 380-382;
4th ed., 381, 382.
Ingram, Part 2, pp. 36, 37.
Mayfield, Book 2, p. 42.
Project Physics, Unit 3, pp. 86, 87.
Williams, p. 174.

- 20 Correct Response: A

Discussion:

In this problem the relationship $PV = NkT$ reduces to $V \propto \frac{T}{P}$

$$\text{giving } \frac{V_2}{V_1} = \frac{T_2}{T_1} \times \frac{P_1}{P_2}$$

$$\text{and since } \frac{T_2}{T_1} = 1.5,$$

$$\frac{P_2}{P_1} = \frac{1}{2}$$

$$\text{then } V_2 = 1.5 \times 2 \times V_1$$

References:

Haber-Schaim, 3rd & 4th ed., p. 376.
Ingram, Part 2, p. 29.
Mayfield, Book 2, pp. 34, 42.
Project Physics, Unit 3, pp. 82, 83.
Williams, p. 191.

- 21–25 Correct Responses: 21 D
22 A
23 A
24 D
25 D

Discussion:

The given information can be summarised as follows:

- (i) X and Y have the same volume and surface area,
- (ii) X and Y contain molecules of the same gas,
- (iii) X and Y are at the same temperature, and
- (iv) there are N molecules in X and $3N$ molecules in Y.

- 21 Density is defined as mass per unit volume. From (ii) and (iv) it is known that the mass in Y is three times the mass in X. From (i) the required ratio is 3:1 (Alternative D).
- 22 At a given temperature the average value of mv^2 for the gas molecules is constant and the same for any gas. Since the mass of molecules in both containers is the same—(ii)—then their average molecular speeds must also be the same. From (iii), X and Y are at the same temperature and so the required ratio is 1:1 (Alternative A).
- 23 The average force per collision with the walls will be determined by the product of the mass and the average speed of the molecules (that is, the momentum). Since both are the same in each vessel then the required ratio is 1:1 (Alternative A).
- 24 From (iv), there are three times as many molecules in Y as in X and hence there will be three times as many collisions per second with the wall in Y as in X (Alternative D).
- 25 The gas pressure is determined by the number of collisions per second with each unit area of the wall and the average force per collision. From items 23 and 24 and condition (i), the required ratio is 3:1 (Alternative D).

References:

Haber-Schaim, 3rd & 4th ed., pp. 370–380.
Ingram, Part 2, pp. 29–35.
Mayfield, Book 2, pp. 36–41.
Project Physics, Unit 3, pp. 81–87.
Williams, pp. 190, 191.

- 26 Correct Response: A

Discussion:

Again, $PV = NkT$

and since P and N are constant
then $V \propto T$

$$\Rightarrow \frac{V_2}{V_1} = \frac{T_2}{T_1}$$

$$\text{thus } T_2 = \frac{V_2}{V_1} \cdot T_1$$

Here, $V_1 = 1 \times 10^{-3} \text{ m}^3$, $V_2 = 2 \times 10^{-3} \text{ m}^3$,
 $T_1 = 300^\circ\text{K}$

$$\begin{aligned} \text{So, } T_2 &= \frac{2 \times 10^{-3}}{1 \times 10^{-3}} \cdot 300 \\ &= 600^\circ\text{K} \end{aligned}$$

References:

Haber-Schaim, 3rd & 4th ed., p. 376.
Ingram, Part 2, pp. 28–30.
Mayfield, Book 2, pp. 34, 43.
Project Physics, Unit 3, pp. 82, 83.
Williams, pp. 188, 189.

- 27 Correct Response: B

Discussion:

The physical quantity represented by the area can be determined from the product of the units of pressure and volume, that is, $P \times V$

$$\begin{aligned} &= \frac{N}{\text{m}^2} \times \text{m}^3 \\ &= N \times \text{m}. \end{aligned}$$

This is equivalent to a joule, which is the unit of work done. (Alternative B)

References:

Haber-Schaim, 3rd & 4th ed., p. 375.
Ingram, Part 2, p. 30.
Mayfield, Book 2, pp. 32, 33.
Project Physics, Unit 3, Ch. 11.

- 28 Correct Response: C

Discussion:

$$PV = NkT$$

V and T are constant, thus $P \propto N$

There are four times as many molecules of argon as there are molecules of helium, thus the ratio of the pressure exerted by the argon molecules to the pressure exerted by the helium molecules is 4:1.

References:

Haber-Schaim, 3rd & 4th ed., pp. 376, 377.
Ingram, Part 2, p. 37.
Mayfield, Book 2, pp. 40–43.
Project Physics, Unit 3, pp. 82, 83.
Williams, p. 191.

29 Correct Response: C

Discussion:

The molecules of a gas must act independently if the gas is to behave as the model of an ideal gas predicts. Because these molecules behave independently, the pressure exerted by the helium molecules will be the same as it was before the introduction of the argon molecules. (Alternative C).

References:

Haber-Schaim, 3rd & 4th ed., pp. 376, 377.
Ingram, Part 2, pp. 31, 37.
Mayfield, Book 2, pp. 36-42.
Project Physics, Unit 3, pp. 82, 83.
Williams, p. 191.

30 Correct Response: D

Discussion:

The pressure has increased in the ratio 7:6. The temperature in the Kelvin scale will increase in the same ratio.

$$PV = NkT$$

V and N are constant.

$$P \propto T$$

$$\frac{P_2}{P_1} = \frac{T_2}{T_1}$$

$$T_2 = \frac{P_2}{P_1} \times T_1$$

$$= \frac{7}{6} \times 300$$

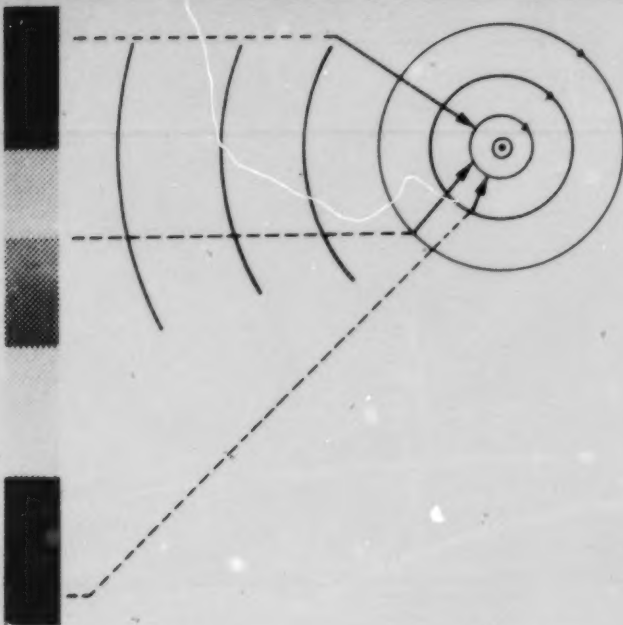
$$= 350$$

Thus the temperature of the air in the tyre is 350°K which, when converted to centigrade, is 77°C (Alternative D).

References:

Haber-Schaim, 3rd & 4th ed., p. 376.
Ingram, Part 2, pp. 29, 30.
Mayfield, Book 2, pp. 34, 42.
Project Physics, Unit 3, pp. 82, 83.
Williams, p. 191.

ACER Physics Unit Tests



Diagnostic Aid 15 Static charges

Description

This diagnostic aid is one of a collection of 21 diagnostic aids corresponding to the 21 separate tests in the *Physics Unit Tests*.

In each diagnostic aid an explanation is provided so that the reasons why the responses are correct or incorrect are available to you.

To gain maximum benefit from the *Physics Unit Tests* weaknesses diagnosed need to be followed up. These diagnostic aids make it possible for you to proceed with this follow up in your own time. If you do not understand the discussion you are advised to seek help from your teacher.

References

The references throughout the Diagnostic Aids have been abbreviated. The abbreviations and full publication details are listed.

- Haber-Schaim: Haber-Schaim, U., Cross, J.B., Dodge, J.H., and Walter, J.A. *PSSC Physics*. 4th ed. Lexington, Mass.: D.C. Heath, 1976. (Reference is also made to 3rd ed.)
- Ingram: Ingram, A.D., Kuhl, D.H., McCarthy, I.E., Sandercock, E.R., Smith, W.F., and Waite, P.J. *Physics: A Laboratory-oriented Approach*. (Study Guide Leaving Part 1, Study Guide Matriculation Part 2). Adelaide: Rigby, 1971, 1972.
- Mayfield: Mayfield, J.M. Parham, R.T., and Webber, B.J. *Fundamentals of Senior Physics*. (Book 1, Book 2). Melbourne: Heinemann Educational Australia Pty Ltd, 1973.
- Project Physics: *Project Physics Course: Programmed Instruction Books* (Kinetic Molecular Theory of Gases, Waves 1-2, Equations 1-3, Vectors 1-3); *Text and Handbook* (Units 1-6). Sydney: Martin Educational, 1970.
- Williams: Williams, J.E., Trinklei, F.E., Metcalfe, H.C., and Lefler, R.W. *Modern Physics*. New York: Holt, Rinehart, & Winston, 1976.

The Australian Council for Educational Research Limited thanks the following publishers for donating textbooks used in referencing the aids: Heinemann Educational Australia Pty Ltd, Richmond, Victoria, for *Fundamentals of Senior Physics*. Rigby Limited, Box Hill, Victoria, for *Physics: A Laboratory-oriented Approach*.

Do not write on this booklet

1 Correct Response: D

Discussion:

A non-conductor, or insulator for electric charge, is one which does not readily allow electric charge to flow through it or over its surface. The only answer here which refers to this property is alternative D.

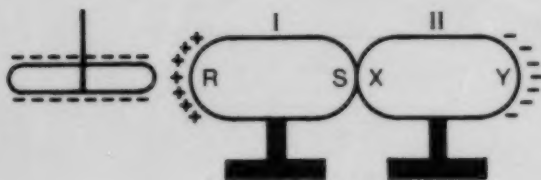
References:

Haber-Schaim, 3rd ed., pp. 399, 400; 4th ed., pp. 392, 393.
Ingram, Part 1, p. 124.
Mayfield, Book 1, p. 145.
Project Physics, Unit 4, p. 52.
Williams, p. 377.

**2 and 3. Correct Responses: 2. A
3. B**

Discussion:

When a charged object is brought close to a neutral conductor, the positive and negative charges in the conductor are shifted around:



Negative charges from I are pushed into II, leaving a surplus of positive charges in I. The diagram shows the resulting charges at R and Y.

References:

Haber-Schaim, 3rd ed., pp. 399, 400, 4th ed., pp. 394, 395.
Ingram, Part 1, p. 235.
Williams, pp. 378, 379.

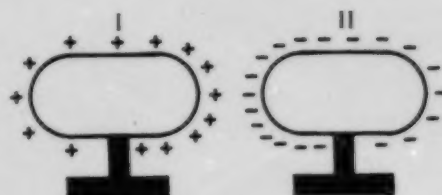
**4 and 5 Correct Responses: 4 A
5 B**

Discussion:

If the conductors I and II are then separated, and finally the rod removed, the following sequence occurs:



and then



Hence I is left with an unbalanced positive charge, and II with a negative charge. (This process is called 'charging by induction')

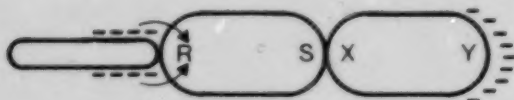
References:

Haber-Schaim, 3rd ed., pp. 402, 403; 4th ed., pp. 394, 395.
Ingram, Part 1, p. 236.
Williams, pp. 378, 379.

6 and 7 Correct Responses: 6 C
7 C

Discussion:

If the rod, with its negative charge, touched at point R, then some of the negative charges would neutralise some of the positive charges at R. Hence, the pair of conductors would have some extra negative charge:



Once all the excess positive charges have been neutralised by all the negative charges from the rod, the negative charges at Y will spread evenly over both conductors (and the rod).



When they are separated the charges will not move much at all:



So both I and II are negatively charged.

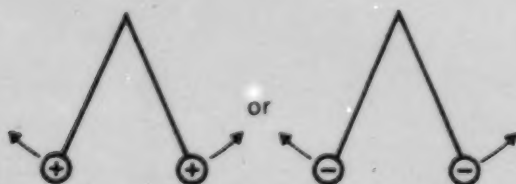
References:

Haber-Schaim, 3rd ed., p. 400; 4th ed., p. 393.
Williams, pp. 378, 379.

8 Correct Response: B

Discussion:

Since both pith balls repel each other, they must have the same type of charge:



If a rod with positive charge repels one ball, then the ball must be positively charged. Hence, the second ball must also be positively charged.

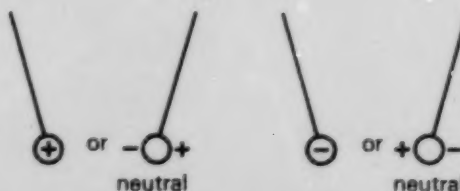
References:

Haber-Schaim, 4th ed., p. 390.
Ingram, Part 1, p. 125.
Mayfield, Book 1, p. 87.
Project Physics, Unit 4, p. 36.
Williams, p. 374.

9 Correct Response: C

Discussion:

If the two pith balls are attracted to each other, then they must be either oppositely charged, or one must be charged while the other is neutral:



If one of the balls attracts a metal rod which is neutral, then the ball must be charged. However, it could be either positively or negatively charged, and there is insufficient information to say which (Alternative C).

References:

Haber-Schaim, 3rd ed., p. 405; 4th ed., p. 396.
Ingram, Part 1, p. 236.
Project Physics, Unit 4, p. 36.
Williams, p. 374.

10 Correct Response: A

Discussion:

The positive charge on the insulator will induce a negative charge on the cap of the GLE leaving excess positive charges on the leaves. Thus the leaves will diverge because they are positively charged.

References:

Haber-Schaim, 3rd ed., p. 404.
Ingram, Part 1, p. 237.
Williams, p. 378.

11 Correct Response: B

Discussion:

The negative charge on the rubber rod will induce a positive charge on the top of the GLE, leaving excess negative charges on the leaves. Thus the leaves will diverge because they are negatively charged.

References:

Haber-Schaim, 3rd ed., p. 404.
Ingram, Part 1, p. 237.
Williams, p. 378.

12 Correct Response: D

Discussion:

The strong negative charge will induce a positive charge on the cap of the GLE. This will further increase the negative charge on the leaves, and they will diverge more.

References:

Haber-Schaim, 3rd ed., p. 404.
Williams, p. 378.

13 Correct Response: E

Discussion:

When the weak negative charge is brought close to the cap of the GLE, a weak negative charge will be induced on the leaves, thus decreasing their excess positive charge. Hence the divergence of the leaves will decrease.

References:

Haber-Schaim, 3rd ed., p. 404.
Williams, p. 378.

14 Correct Response: K

Discussion:

When the positively charged rod is brought near to *X*, a negative charge will be induced on *X* and a positive charge on *Y*. Since the rod has a strong positive charge, the charge on *Y* will be fairly strong. Now *Y* will induce a negative charge on the cap of the GLE, and hence the leaves will collapse and then diverge again due to an excess of positive charges.

References:

Haber-Schaim, 3rd ed., p. 403; 4th ed., p. 395.
Ingram, Part 1, p. 236.
Williams, p. 378.

15 Correct Response: K

Discussion:

From item 14, we know that the leaves have an excess positive charge. When *X* is brought into contact with *Y*, it will neutralise *Y*. The leaves of the electroscope will then return to their original condition of carrying a weak negative charge. Thus they will collapse and then diverge again.

References:

Haber-Schaim, 3rd ed., p. 403; 4th ed., p. 395.
Williams, p. 378.

16 Correct Response: B

Discussion:

The essential difference between insulators and conductors is demonstrated by the behaviour of charge placed on them. For insulators the charge remains where it is placed, whereas for conductors the charge quickly distributes itself over the entire surface.

References:

Haber-Schaim, 3rd ed., pp. 399, 400; 4th ed., pp. 394, 395.
Ingram, Part 1, p. 124.
Mayfield, Book 1, p. 145.
Project Physics, Unit 4, p. 52.
Williams, p. 378.

17 Correct Response: C

Discussion:

While it is true that metals are good conductors, it is not necessarily true that non metals are good insulators. For example, carbon is a conductor and a non metal. Thus, we do not have enough information to decide.

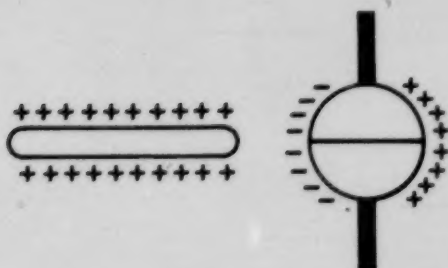
References:

Haber-Schaim, 3rd ed., p. 402; 4th ed., pp. 393, 394.
Mayfield, Book 1, p. 145.
Williams, p. 378.

18 Correct Response: D

Discussion:

The positively charged rod will induce positive and negative charges to appear on the hemispheres:



Note that each hemisphere receives half the positive charge and half the negative charge. When the hemispheres are separated and the charged rod removed, the positive and negative charges on each hemisphere will merge and neutralise each other, so that they will be both neutral.

References:

Haber-Schaim, 3rd ed., p. 403.
Ingram, Part 1, p. 236.

19 Correct Response: A

Discussion:

Copper and the human body are both good conductors. When the fur rubs the copper rod, there will be a transfer of charge between the rod and the fur. However, the charge on the rod will be shared with the body and the earth (if the body is earthed).

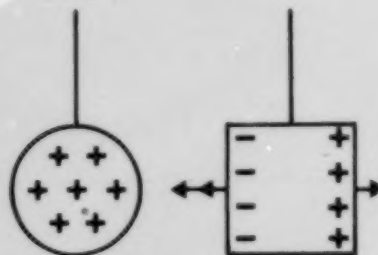
References:

Haber-Schaim, 3rd ed., p. 401.
Ingram, Part 1, p. 124.
Mayfield, Book 1, p. 145.

20 Correct Response: D

Discussion:

Electrons are free to move over the surface of the metal foil. When the charged ball is brought close to the foil, electrons will be attracted by the positive charge on the ball, and will move to the end closest to this positive charge. This will leave an unbalanced positive charge at the other end of the foil.



The force of attraction of the positive ball on the negative charges on the foil will be greater than the repulsion of the positive ball on the positive charges on the foil. Hence, the foil will move towards the ball.

References:

Haber-Schaim, 3rd ed., p. 405; 4th ed., p. 396.
Ingram, Part 1, p. 236.
Williams, p. 378.

21 Correct Response: B

Discussion:

If the ball is encased in the hemispheres, the hemispheres will have a charge induced on them:



As shown in the diagram, they are positive on the outside, and act just as the positive ball did before. Alternatively, if the foil is enclosed, there will be no electric force inside the hemispheres, and so the foil will not be affected this time.

References:

Ingram, Part 1, pp. 138, 238.
Project Physics, Unit 4, p. 40.

22 Correct Response: A

Discussion:

The only charged particle able to move readily around in solids is the electron, which has a negative charge. Hence, the flannel must give up electrons to the rod.

23 Correct Response: D

Discussion:

The sphere could be attracted to the charged object if it had opposite charge, or if it was neutral. It cannot be said with certainty which it is here, without more information.

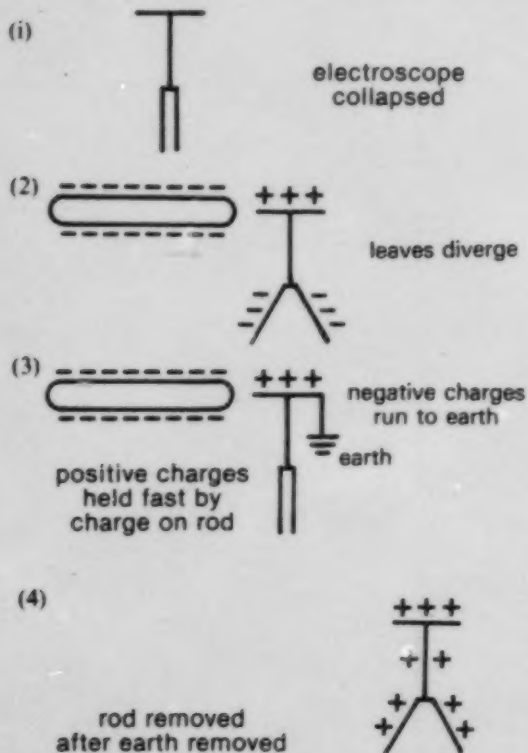
References:

Haber-Schaim, 3rd ed., p. 405; 4th ed., p. 396.
Ingram, Part 1, p. 236.
Williams, p. 378.

24 Correct Response: A

Discussion:

The process described here follows this sequence:



Hence, the GLE is now positively charged.

References:

Ingram, Part 1, p. 237.

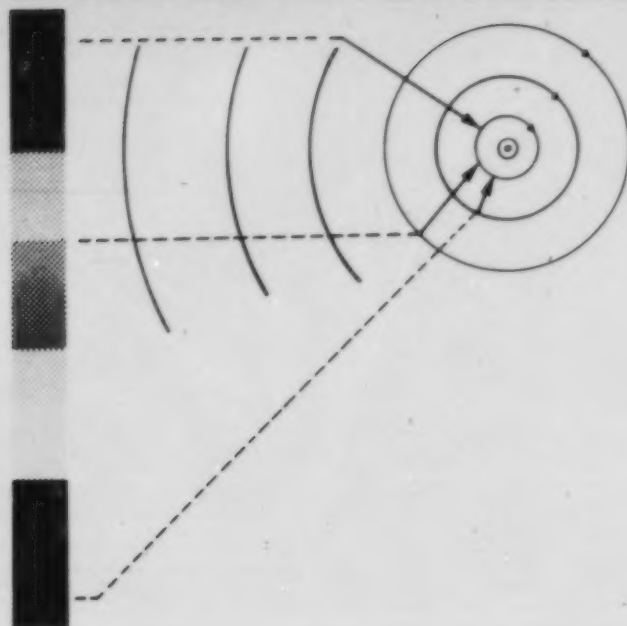
25 Correct Response: D

Discussion:

Electrons from the metal cap will move off the surface and onto positively charged ions in the air. This is because electrons move readily in solids whereas positive charges do not. Alternative D is therefore the correct response.

References:

Haber-Schaim, 3rd ed., p. 408; 4th ed., p. 434.



Diagnostic Aid 16 Electric field and potential difference

Description

This diagnostic aid is one of a collection of 21 diagnostic aids corresponding to the 21 separate tests in the *Physics Unit Tests*.

In each diagnostic aid an explanation is provided so that the reasons why the responses are correct or incorrect are available to you.

To gain maximum benefit from the *Physics Unit Tests* weaknesses diagnosed need to be followed up. These diagnostic aids make it possible for you to proceed with this follow up in your own time. If you do not understand the discussion you are advised to seek help from your teacher.

References

The references throughout the Diagnostic Aids have been abbreviated. The abbreviations and full publication details are listed.

- Haber-Schaim: Haber-Schaim, U., Cross, J.B., Dodge, J.H., and Walter, J.A. *PSSC Physics*. 4th ed. Lexington, Mass.: D.C. Heath, 1976. (Reference is also made to 3rd ed.)
- Ingram: Ingram, A.D., Kuhl, D.H., McCarthy, I.E., Sandercock, E.R., Smith, W.F., and Waite, P.J. *Physics: A Laboratory-oriented Approach*. (Study Guide Leaving Part 1, Study Guide Matriculation Part 2). Adelaide: Rigby, 1971, 1972.
- Mayfield: Mayfield, J.M. Parnam, R.T., and Webber, B.J. *Fundamentals of Senior Physics*. (Book 1, Book 2). Melbourne: Heinemann Educational Australia Pty Ltd, 1973.
- Project Physics: *Project Physics Course: Programmed Instruction Books* (Kinetic Molecular Theory of Gases, Waves 1-2, Equations 1-3, Vectors 1-3); *Text and Handbook* (Units 1-6). Sydney: Martin Educational, 1970.
- Williams: Williams, J.E., Trinkle, F.E., Metcalfe, H.C., and Lefler, R.W. *Modern Physics*. New York: Holt, Rinehart, & Winston, 1976.

The Australian Council for Educational Research Limited thanks the following publishers for donating textbooks used in referencing the aids: Heinemann Educational Australia Pty Ltd, Richmond, Victoria, for *Fundamentals of Senior Physics*. Rigby Limited, Box Hill, Victoria, for *Physics: A Laboratory-oriented Approach*.

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1 Correct Response: D

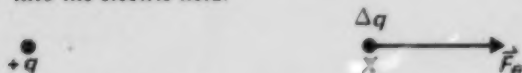
Discussion:

The strength of an electric field E is defined by

$$\vec{E} = \frac{\vec{F}_e}{\Delta q}$$

The direction of an electric field is the

same as that of the electric force ($\vec{F}_e$) experienced by a small positive test charge (Δq) when introduced into the electric field.



The test charge Δq , if placed at X, would experience a coulomb force of repulsion in direction D.

References:

Haber-Schaim, 3rd ed., p. 421.

Ingram, Part 1, pp. 130, 131.

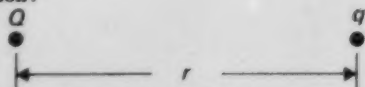
Mayfield, Book 1, p. 91.

Project Physics, Unit 4, p. 47.

Williams, p. 382.

2 Correct Response: B

Discussion:



If the zero of potential energy of a system of charges Q and q is taken at infinite separation, the electric potential energy of the system at separation r is given by the relation,

$$U = \frac{KQq}{r} \quad (K = \frac{1}{4\pi\epsilon_0} \text{ in a vacuum})$$

The electric potential at a point is defined as the electrical potential energy associated with unit charge. At a distance r from Q , the electric potential is given by the relation

$$V = \frac{KQ}{r}$$

The electric potential V at a point due to a charge Q is inversely proportional to the distance r of the point from the charge

$$\Rightarrow V \propto \frac{1}{r}$$

$$\Rightarrow \frac{V_f}{V_i} = \frac{r_i}{r_f}$$

Now $V_i = 1.8 \times 10^4$ V, $r_i = 0.2$ m, $r_f = 0.3$ m,

$$\text{hence } \frac{V_f}{1.8 \times 10^4} = \frac{0.2}{0.3}$$

$$\Rightarrow V_f = \frac{2}{3} \times 1.8 \times 10^4$$

$$\Rightarrow V_f = 1.2 \times 10^4 \text{ V}$$

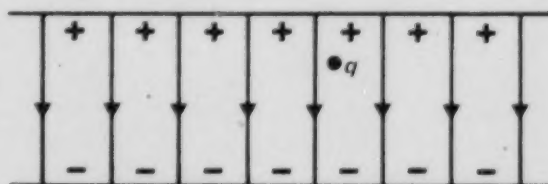
References:

Haber-Schaim, 3rd ed., pp. 424, 426.

Ingram, Part 1, pp. 103, 104, 131, 132.

3 Correct Response: D

Discussion:



The electric field between a pair of oppositely charged parallel plates is uniform. The electric field lines are evenly spaced and parallel to each other. This means that the electric force $\vec{F}_e$ experienced by an electric charge Δq placed anywhere between the parallel plates has the same size and direction.

Now the definition of electric field strength is given by

$$\vec{E} = \frac{\vec{F}_e}{\Delta q} \quad (\text{see item 1})$$

Since F_e and Δq are constant, then E has the same value of $2 \times 10^3 \text{ N C}^{-1}$ at any point between the plates.

References:

Haber-Schaim, 3rd ed., pp. 421–424.

Ingram, Part 1, p. 134.

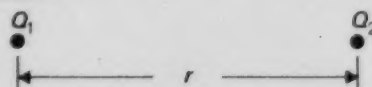
Mayfield, Book 1, p. 95.

Project Physics, Unit 4, pp. 47–49.

Williams, p. 383.

4 Correct Response: A

Discussion:



The magnitude of the electrostatic force acting on two point charges Q_1 and Q_2 which are separated by a distance r , is given by Coulomb's law,

$$F_e = \frac{KQ_1Q_2}{r^2} \quad (K = \frac{1}{4\pi\epsilon_0} \text{ in a vacuum})$$

In the question, Q_1 , Q_2 and K are constant

$$\Rightarrow F_e \propto \frac{1}{r^2}$$

The electric force is inversely proportional to the square of the separation of the point charges

$$\Rightarrow \frac{F_f}{F_i} = \frac{r_i^2}{r_f^2}$$

Here, $F_i = 9 \times 10^{-14}$ N, $r_i = 2$ m, $r_f = 3$ m

$$\Rightarrow \frac{F_f}{9 \times 10^{-14}} = \frac{2^2}{3^2}$$

$$\Rightarrow F_f = \frac{4}{9} \times 9 \times 10^{-14}$$

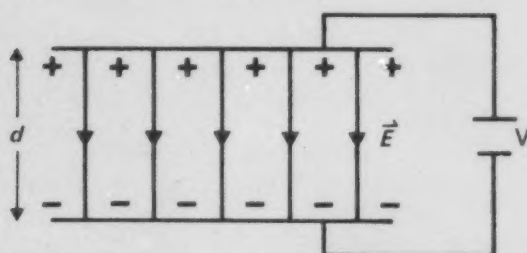
$$\Rightarrow F_f = 4 \times 10^{-14} \text{ N}$$

References:

Haber-Schaim, 3rd ed., pp. 419-421.
 Ingram, Part 1, pp. 125-127.
 Mayfield, Book 1, p. 89.
 Project Physics, Unit 4, pp. 37-41.
 Williams, p. 380.

5 Correct Response: C

Discussion:



When a battery of size V volts is connected across a pair of parallel plates, an electric potential difference of V volts is set up across the parallel plates. This means that V joules per coulomb of work can be done by the established electric field in transferring positive charge from the positive to the negative plate.

In the question $V = 2500$, hence a 2500 V battery leads to $2500 \frac{\text{J}}{\text{C}}$ of work done by the electric field, that is, 2500 joules of work is done to transfer 1 coulomb of charge

$\Rightarrow x$ joules of work is done to transfer 8.0×10^{-19} coulomb of charge

$$\Rightarrow \frac{x}{2500} = \frac{8.0 \times 10^{-19}}{1}$$

$$\Rightarrow x = 8.0 \times 10^{-19} \times 2500$$

$$\Rightarrow x = 2.0 \times 10^{-15} \text{ J}$$

(Alternative C).

Alternatively, from $\vec{E} = \frac{\vec{F}_e}{\Delta q}$ (see item 1)

it can be shown that $E = \frac{V}{d}$,

Here, V is the potential difference across the plates and d is the distance between the plates.

Since $V = 2500$, $d = 0.05 \text{ m}$ and $Q = 8.0 \times 10^{-19} \text{ C}$

$$E = \frac{2500}{0.05}$$

$$\Rightarrow E = 5 \times 10^4 \text{ V m}^{-1}$$

$$= 5 \times 10^4 \text{ N C}^{-1}$$

The work done by the electric force in transferring charge from one plate to the other is given by

$$\text{W.D.} = F_e \times d$$

and since $F_e = E\Delta q$

$$\text{Work} = E\Delta q = d$$

$$= 5 \times 10^4 \times 8.0 \times 10^{-19}$$

$$\times 0.05$$

$$= 2.0 \times 10^{-15} \text{ N m}$$

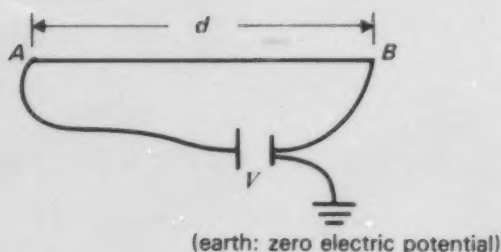
or work done by the electric force $= 2.0 \times 10^{-15} \text{ J}$

References:

Haber-Schaim, 3rd ed., pp. 421-424, 457-459, 471.
 Ingram, Part 1, pp. 134, 135.
 Mayfield, Book 1, pp. 117, 118, 124, 133.
 Project Physics, Unit 4, pp. 47-49, 56, 57.
 Williams, p. 386.

- 6-11 Correct Responses: 6 C
7 B
8 A
9 B
10 B
11 A

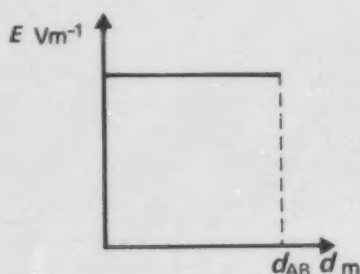
Discussion:



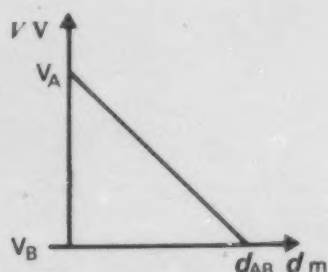
When a battery V volt is connected across a uniform wire of length d metre, a uniform electric field is set up within the wire. The size of the electric field is given by the electric potential difference V divided by the length of wire d .

$$E = \frac{V}{d} \quad (\text{analogous to the parallel plate situation})$$

A graph of the electric field strength $E \text{ V m}^{-1}$ versus length that wire $d \text{ m}$ would be:



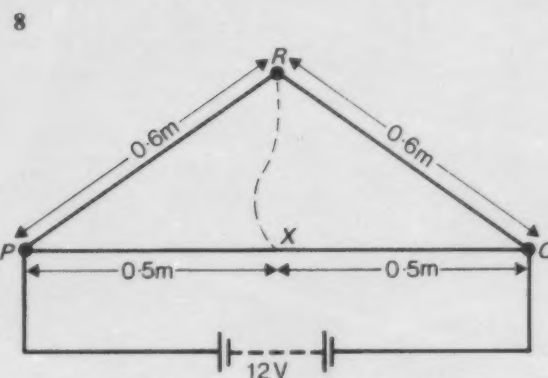
If the negative terminal of the battery is earthed (zero electric potential), then the electric potential decreases uniformly when moving from end A to B. A graph of electric potential $V \text{ V}$ versus length of wire $d \text{ m}$ would be:



The slope of the electric potential V versus length d graph is a measure of electric field strength E .

- 6 The applied electric potential difference across the two points P, Q is 12 V. Hence the electric potential difference around path PRQ is the same as the direct path PQ . An electric potential difference of 12 volts means that 12 joules of energy is available to transfer each coulomb of charge from P to Q via either path (Alternative C).

- 7 From the relationship $E = \frac{V}{d}$, it can be seen that $V \propto d$, E being constant for a given length of wire. The electric potential at R decreases by a factor of one half that at P when moving around PRQ because $PR = \frac{1}{2} PRQ$. The point X which has the same electric potential as point R along path PQ will be located by $PX = \frac{1}{2} PQ$, that is $\frac{1}{2} \times 1.0 \text{ m} = 0.5 \text{ m}$ (Alternative B).



The points R and X are at the same electric potential. Consequently there is no electric potential difference between the points R and X . From $E = \frac{V}{d}$ and

$E = \frac{F_e}{\Delta q}$, in wire RX , it can be seen that $E = 0$ because $V = 0$, and $F_e = 0$ because $E = 0$. Hence, there will be no electric charge transported along RX . (Alternative A).

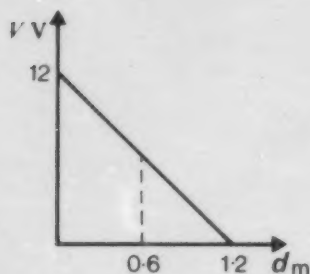
- 9 The point X is a quarter of the way along the path PQ and the electric potential has decreased by a factor of $\frac{1}{4}$ [$V \propto d$]. The point on the path PRQ which has the same electric potential will be a quarter of the way along the path PRQ .

$$\frac{1}{4} \text{ of } 0.6 + 0.6 \text{ m} = 0.3 \text{ m}$$

(Alternative B)

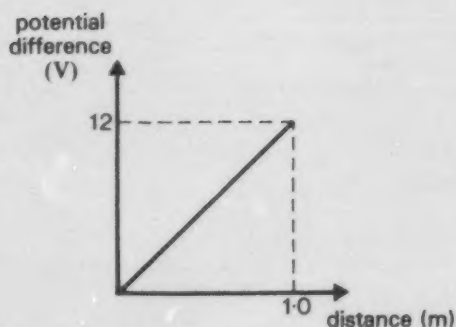
- 10 The two wires PR and RQ are the same type, cross sectional area and length and may be considered as one wire of length 1.2 m.

Now the electric potential V , is directly proportional to the length d , since the electric field strength E , will be the same in both wires PR and RQ . Therefore, the electric potential decreases uniformly when moving from point P (12 V) via R to point Q (0 V)



(Alternative B)

- 11 As the point X moves along PQ , the electric potential at X decreases uniformly with distance along the wire. However, the difference in electric potential between points P and X increases uniformly from 0 V to 12 V



(Alternative A)

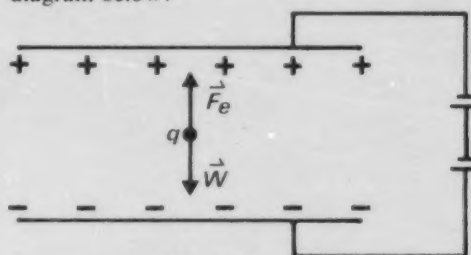
References:

Haber-Schaim, 3rd ed., pp. 468–472.
Ingram, Part 1, pp. 148, 149.
Williams, pp. 385, 386.

- 12 and 13 Correct Responses: 12 C
13 B

Discussion:

The forces acting on the sphere are shown in the diagram below:



- 12 Using $\vec{\Sigma F} = m\vec{a}$ (Newton's law)
 $\Rightarrow F_e - W = ma$

The small charged sphere is suspended in a uniform electric field, therefore velocity, $v = 0$ and acceleration, $a = 0$.

$$\Rightarrow F_e = W$$

From the definition of electric field strength

$$\vec{E} = \frac{\vec{F}_e}{\Delta q}$$

Here, $F_e = W = 1.3 \times 10^{-14}$ N, $\Delta q = 3.2 \times 10^{-19}$ C

$$\Rightarrow E = \frac{1.3 \times 10^{-14}}{3.2 \times 10^{-19}}$$

$$\Rightarrow E = 4.1 \times 10^4 \text{ N C}^{-1}$$

(Alternative C)

- 13 If the new charge on the sphere of 4.8×10^{-19} C is inserted between the parallel plates, the electric force F_e acting on it would increase by a factor of $\frac{3}{2}$

Since $F_e = E \Delta q$ (E constant)

$$\Rightarrow \frac{F_{\text{new}}}{F_{\text{old}}} = \frac{\Delta q_{\text{new}}}{\Delta q_{\text{old}}} = \frac{4.8 \times 10^{-19}}{3.2 \times 10^{-19}}$$

$$\Rightarrow \frac{F_{\text{new}}}{F_{\text{old}}} = \frac{3}{2}$$

$$\Rightarrow F_{\text{new}} = \frac{3}{2} F$$

To keep the newly charged sphere in balance ($F_e = W$), the new electric force must be decreased by a factor of $\frac{2}{3}$. Since $F_e = E \Delta q$ and Δq constant (4.8×10^{-19} C), then

$$F \propto E, \text{ and}$$

the new electric field must be $\frac{2}{3}$ that of the old electric field value

(Alternative B)

References:

Haber-Schaim, 3rd ed., pp. 421–424, 426–431.
Ingram, Part 1, pp. 134, 135.
Mayfield, Book 1, pp. 91, 95, 97.
Project Physics, Unit 4, pp. 47–51.
Williams, p. 382.

14 Correct Response: D

Discussion:

Refer to item 3. Since $E = \frac{\vec{F}_e}{\Delta q}$ and electric field strength (E) is constant between a pair of oppositely charged plates, an electron would experience the same size electric force (F_e) anywhere between the plates.

References:

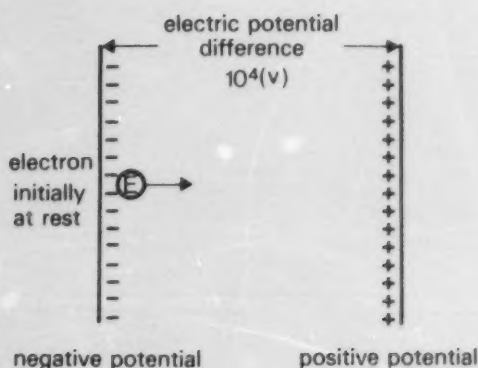
Haber-Schaim, 3rd ed., pp. 421–424, 426–431.
Ingram, Part 1, p. 134.
Mayfield, Book 1, p. 95.
Project Physics, Unit 4, pp. 47–49.
Williams, p. 383.

15 Correct Response: C

Discussion:

Refer to item 5. There are two approaches to this question.

Solution A:



Since an electric potential difference $V = 10^4$ V exists, this means that 10^4 joules of work can be done in transferring a coulomb of electric charge. In this example, the work done on the electrons is transferred to kinetic energy.

Work done = change in kinetic energy

$$\Rightarrow \text{W.D.} = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

since $v_i = 0$ (electrons initially at rest)

$$\Rightarrow \text{W.D.} = \frac{1}{2} m v_f^2 = \text{final kinetic energy}$$

Hence, 1 C of electrons gain 10^4 J of E_k

$$\Rightarrow 6.2 \times 10^{18} \text{ electrons gain } 10^4 \text{ J of } E_k$$

$$\Rightarrow 1 \text{ electron gains } \frac{10^4 \text{ J}}{6.2 \times 10^{18}} = 1.6 \times 10^{-15} \text{ J}$$

(Alternative C)

Solution B:

A better approach involves the unit of energy called the electron volt (eV). When an electron (or any single charged particle) is accelerated through an electric potential difference of 1 V, it gains 1 eV of kinetic energy. One electron volt of energy is equivalent to 1.6×10^{-19} J.

In the example, an electron accelerated through an electric potential difference of 10^4 V would gain 10^4 eV of kinetic energy.

$$\Rightarrow E_{K \text{ gained}} = E_{Kf} - E_{Ki}$$

$$\text{and since } E_{Ki} = 0$$

$$\Rightarrow E_{Kf} = 10^4 \text{ eV}$$

$$= 10^4 \times 1.6 \times 10^{-19} \text{ J}$$

$$\Rightarrow E_{Kf} = 1.6 \times 10^{-15} \text{ J}$$

References:

Haber-Schaim, 3rd ed., pp. 424–426, 446, 461.
Ingram, Part 1, pp. 144, 145.
Mayfield, Book 1, p. 119.
Project Physics, Unit 4, pp. 55–57.
Williams, pp. 385, 386.

16–19 Correct Responses: 16 D

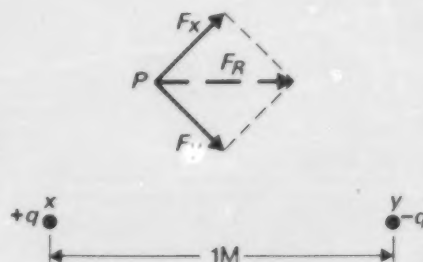
17 D

18 A

19 A

Discussion:

16



If a small test charge (Δq) is introduced at point P, it will experience a force of repulsion $\vec{F}_x$ due to $+q$ and a force of attraction $\vec{F}_y$ due to $-q$. The magnitudes of the two forces F_x and F_y are equal because from Coulomb's law $F = \frac{kQ_1Q_2}{d^2}$,

$$F_x = \frac{k(+q)\Delta q}{d^2} \quad \text{and} \quad F_y = \frac{k(-q)\Delta q}{d^2}$$

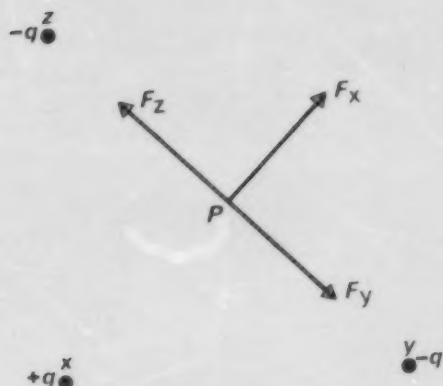
with $d = 0.7$ m in both cases.

The resultant electric force acting on the test charge is found by vector addition (parallelogram rule used in diagram) and points in direction D. Since

$\vec{E} = \frac{\vec{F}}{\Delta q}$, the direction of the electric field is the same as that of the resultant force acting on the test charge.

(Alternative D)

- 17 The explanation is analogous to that above except the small test charge Δq is replaced by charge q . The resultant electric force points in direction D.



18

As in item 16, consider a small test charge introduced at point P. The small test charge will experience three electric forces $\vec{F}_x$, $\vec{F}_y$ and $\vec{F}_z$ as illustrated. The forces $\vec{F}_x$ and $\vec{F}_y$ are equal in magnitude and opposite in direction, hence the resultant force acting on the small test charge is equivalent to $\vec{F}_z$. The direction of the electric field is the same as the resultant force acting on the test charge ($\vec{E} = \frac{\vec{F}}{\Delta q}$)—in direction A.

- 19 If the charges at X, Y and Z are all doubled, the electric forces ($\vec{F}_x$, $\vec{F}_y$ and $\vec{F}_z$) acting on the small test charge will all be quadrupled in size ($F_e \propto Q_1 Q_2$) and in the same directions as above in item 18. The direction of the resultant force is the same as $\vec{F}_x$ which will be that of the electric field—in direction A.

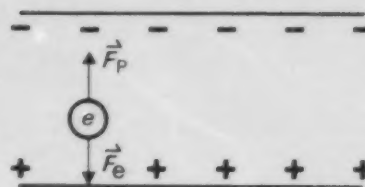
References:

Haber-Schaim, 3rd ed., pp. 419–421.
Ingram, Part 1, pp. 125–127.
Mayfield, Book 1, pp. 89, 94.
Project Physics, Unit 4, pp. 37–41.
Williams, pp. 382, 383.

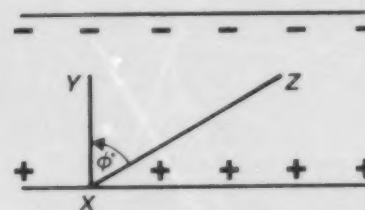
- 20 Correct Response: C

Discussion:

Solution I:



The electron experiences a downward electric force $\vec{F}_e$ between the parallel plates. To move the electron slowly upwards toward the negative plate, a pulling force $\vec{F}_p$ (F_p just greater than F_e initially) is required. Work done is measured by the size of the force by the distance moved in the direction of the force.



The work done on the first electron along path XY is given by $WD_{xy} = F_p d_{xy}$.

The work done on the second electron along path XY is given by WD_{xz} = the component along XZ of $\vec{F}_p \times d_{xz}$.

If we define $\angle YXZ = \phi^\circ$, the component of F_p along XZ is $F_p \cos \phi^\circ$

$$\Rightarrow WD_{xz} = F_p \cos \phi^\circ d_{xz} \\ = F_p (d_{xz} \cos \phi^\circ)$$

$$\text{but } d_{xz} \cos \phi^\circ = d_{xy}$$

$$\Rightarrow WD_{xz} = F_p d_{xy}$$

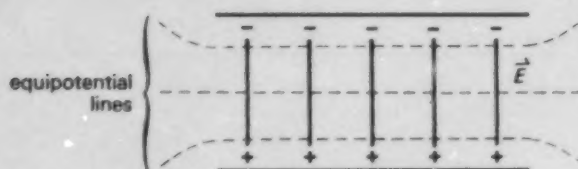
hence the ratio

work done on first electron (path XY)

work done on second electron (path XZ)

$$= 1 \quad (\text{Alternative C})$$

Solution II: A better solution is to recognise that the points Y and Z are both situated the same distance from the positive (or negative) plate and hence, are located on the same equipotential line (2D) or surface (3D) between the parallel plates. All points which lie on an equipotential line or surface have the same electric potential.



Thus, the work done against the electric field E in moving an electron from point X to any point on the equipotential line through Y and Z will be the same

$$\Rightarrow \frac{\text{work done on first electron (path XY)}}{\text{work done on second electron (path XZ)}} = 1$$

References:

Haber-Schaim, 3rd ed., p. 468.

Ingram, Part 1, p. 134.

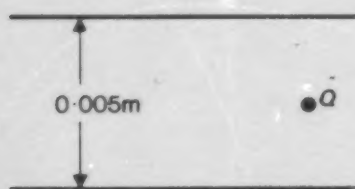
Mayfield, Book 1, pp. 120–123.

Williams, p. 386.

- 21–24 Correct Responses: 21 B
22 D
23 B
24 D

Discussion:

21



$$Q = 6.4 \times 10^{-19} \text{ C}$$

$$F_e = 2.56 \times 10^{-14} \text{ N}$$

From the definition of electric field strength

$$\begin{aligned} \vec{E} &= \frac{\vec{F}_e}{\Delta q} \\ \Rightarrow E &= \frac{F_e}{Q} \\ &= \frac{2.56 \times 10^{-14} \text{ N}}{6.4 \times 10^{-19} \text{ C}} \\ &= 4.0 \times 10^4 \text{ N C}^{-1} \end{aligned}$$

A newton per coulomb (N C^{-1}) is equivalent to a volt per metre (V m^{-1})

$$\Rightarrow E = 4.0 \times 10^4 \text{ V m}^{-1}$$

- 22 Again using the definition of electric field strength

$$\begin{aligned} \vec{E} &= \frac{\vec{F}_e}{\Delta q} \\ \Rightarrow E &= \frac{F_e}{Q} \\ \Rightarrow F_e &= EQ \end{aligned}$$

In this example, $Q = 3.2 \times 10^{-19} \text{ C}$ and

$$E = 4.0 \times 10^4 \frac{\text{V}}{\text{m}}, \text{ from item 21.}$$

$$\begin{aligned} \Rightarrow F_e &= 4.0 \times 10^4 \frac{\text{V}}{\text{m}} \times 3.2 \times 10^{-19} \text{ C} \\ &= 4.0 \times 10^4 \frac{\text{N}}{\text{C}} \times 3.2 \times 10^{-19} \text{ C} \\ \Rightarrow F_e &= 1.28 \times 10^{-14} \text{ N} \end{aligned}$$

(Alternative D)

- 23 From the definition $E = \frac{V}{d}$ for electric field strength

$$\Rightarrow V = Ed$$

In this example, $E = 2 \times 10^3 \text{ N C}^{-1} = 2 \times 10^3 \text{ V m}^{-1}$ and $d = 0.005 \text{ m}$

$$\begin{aligned} \Rightarrow V &= 2 \times 10^3 \frac{\text{V}}{\text{m}} \times 5 \times 10^{-3} \text{ m} \\ \Rightarrow V &= 10 \text{ V} \end{aligned}$$

24



A negatively charged body experiences an upward electric force since it is effectively attracted by the positive plate and repelled by the negative plate. (Alternative D).

References:

Haber-Schaim, 3rd ed., pp. 421, 471.

Ingram, Part 1, pp. 134, 135.

Mayfield, Book 1, pp. 91, 124, 125.

Project Physics, Unit 4, pp. 47, 56.

Williams, pp. 382, 383.

25 Correct Response: C

Discussion:

An equipotential line represents a line where the electric potential is the same at each point. No work is done by the electric field in transferring charge along an equipotential line. In the parallel plate case of item 20, the work done in transferring an electron along path YZ is zero. This is reasonable since the electric field ($\vec{E}$) and the electric force ($\vec{F}_e$) are both at right angles to the path YZ. It follows that electric field and equipotential lines meet at right angles.

Hence, it is possible to determine the shape of the electric field lines since they meet equipotential lines at right angles. Secondly, we can determine the direction of the electric field lines since they move in the direction of decreasing potential.

(Alternative C)

References:

Haber-Schaim, 3rd ed., p. 468.

Ingram, Part 1, p. 104.

Mayfield, Book 1, pp. 120–123.

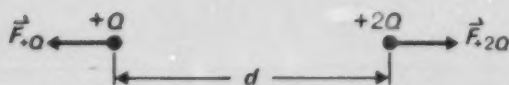
Williams, pp. 382–383.

26 Correct Response: A

Discussion:

From Coulomb's law, $F_e = \frac{KQ_1Q_2}{d^2}$, the electric

force acting on the $+Q$ point charge is proportional to the product of the charges, $Q \times 2Q$. Similarly, the electric force acting on the $+2Q$ point charge is proportional to the product of the charges, $Q \times 2Q$. Hence, the forces experienced by both charges are equal in size ($F_{1Q} = F_{2Q}$).



References:

Haber-Schaim, 3rd ed., pp. 419–421.

Ingram, Part 1, pp. 125–127.

Mayfield, Book 1, p. 89.

Project Physics, Unit 4, pp. 37–41.

Williams, p. 383.

27 29 Correct Responses: 27 C

28 A

29 A

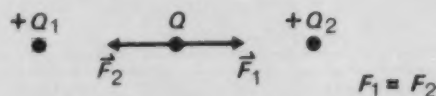
Discussion:

Electric field lines leave positively charged conductors and terminate on negatively charged conductors. The direction of an electric field is the same as that of the resultant electric force experienced by a small positive test charge introduced into the electric field.

27 The electric field pattern alternative C is not possible because the electric field lines both arrive at and leave the left hand charged body at the same time.

28 In a situation where there are two charged bodies with like charges, all the electric field lines leave or arrive at both bodies. Alternative A is correct.

29 If there is no net electrical force, there will be no resultant electrical field hence no electric field lines in a diagrammatic representation. The only situation where this can occur is in alternative A. Assuming equal charges, the electric force ($\vec{F}_1$) due to Q_1 is equal in size to the electric force ($\vec{F}_2$) due to Q_2 on a charge Q at the midpoint of the line joining the two charges.



The resultant force acting on Q will be zero.

References:

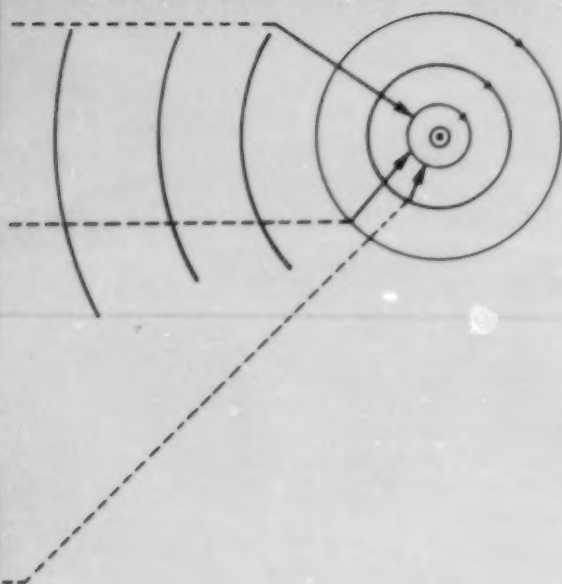
Haber-Schaim, 3rd ed., pp. 421–425.

Ingram, Part 1, pp. 100, 101.

Mayfield, Book 1, pp. 92–96.

Project Physics, Unit 4, pp. 48, 49.

Williams, pp. 382, 383.



Diagnostic Aid 17 Current electricity

Description

This diagnostic aid is one of a collection of 21 diagnostic aids corresponding to the 21 separate tests in the *Physics Unit Tests*.

In each diagnostic aid an explanation is provided so that the reasons why the responses are correct or incorrect are available to you.

To gain maximum benefit from the *Physics Unit Tests* weaknesses diagnosed need to be followed up. These diagnostic aids make it possible for you to proceed with this follow up in your own time. If you do not understand the discussion you are advised to seek help from your teacher.

References

The references throughout the Diagnostic Aids have been abbreviated. The abbreviations and full publication details are listed.

- Haber-Schaim: Haber-Schaim, U., Cross, J.B., Dodge, J.H., and Walter, J.A. *PSSC Physics*. 4th ed. Lexington, Mass.: D.C. Heath, 1976. (Reference is also made to 3rd ed.)
- Ingram: Ingram, A.D., Kuhl, D.H., McCarthy, I.E., Sandercock, E.R., Smith, W.F., and Waite, P.J. *Physics: A Laboratory-oriented Approach*. (Study Guide Leaving Part 1, Study Guide Matriculation Part 2). Adelaide: Rigby, 1971, 1972.
- Mayfield: Mayfield, J.M. Parham, R.T., and Webber, B.J. *Fundamentals of Senior Physics*. (Book 1, Book 2). Melbourne: Heinemann Educational Australia Pty Ltd, 1973.
- Project Physics: *Project Physics Course: Programmed Instruction Books* (Kinetic Molecular Theory of Gases, Waves 1-2, Equations 1-3, Vectors 1-3); *Text and Handbook* (Units 1-6). Sydney: Martin Educational, 1970.
- Williams: Williams, J.E., Trinklei, F.E., Metcalfe, H.C., and Lefler, R.W. *Modern Physics*. New York: Holt, Rinehart, & Winston, 1976.

The Australian Council for Educational Research Limited thanks the following publishers for donating textbooks used in referencing the aids: Heinemann Educational Australia Pty Ltd, Richmond, Victoria, for *Fundamentals of Senior Physics*. Rigby Limited, Box Hill, Victoria, for *Physics: A Laboratory-oriented Approach*.

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- 1-4 Correct Responses: 1 A
2 B
3 B
4 A

Discussion:

- 1 The 4Ω and 2Ω resistors are joined in series with a source of EMF connected across them. Ohm's law states that the ratio

$$\frac{\text{applied potential difference}}{\text{current}} = \text{constant called electrical resistance}$$

that is,
$$\frac{V}{I} = R$$

Rearranging Ohm's law, $V = IR$. The potential difference across each resistance will be

$$V_{4\Omega} = I \times 4, \quad V_{2\Omega} = I \times 2$$

The electrical current through the 4Ω and 2Ω resistors is the same

$$\Rightarrow \frac{V_{4\Omega}}{V_{2\Omega}} = \frac{I \times 4}{I \times 2} = \frac{2}{1}$$

- 2 Since the 4Ω and 2Ω resistors are joined in series, the same electrical current passes through each

$$\Rightarrow \frac{I_{4\Omega}}{I_{2\Omega}} = \frac{1}{1}$$

- 3 When an electrical current passes through a resistor, energy in the form of heat is transferred to the surroundings. The rate at which energy is transferred is termed the power (P) and is given by $P = VI$. Using Ohm's law, $V = IR$

$$P = I^2 R$$

The power dissipated in each resistor is given by

$$P_{4\Omega} = I^2 \times 4, \quad P_{2\Omega} = I^2 \times 2$$

The electrical current through each resistor is the same

$$\Rightarrow \frac{P_{4\Omega}}{P_{2\Omega}} = \frac{I^2 \times 4}{I^2 \times 2} = \frac{2}{1}$$

- 4 Ohm's law states that $\frac{V}{I} = R$ (see item 1). A

mathematical expression of Ohm's law is $I = \frac{V}{R}$

References:

Haber-Schaim, 3rd ed., pp. 477, 481.
Ingram, Part 1, pp. 150, 154.
Mayfield, Book 1, pp. 148-152, 173.
Project Physics, Unit 4, pp. 58, 59.
Williams, pp. 418-420.

- 5 and 6 Correct Responses: 5 C
6 D

Discussion:

- 5 The potential difference across a resistance is given by $V = IR$ after re-arrangement of Ohm's law.

$$\Rightarrow V_{3\Omega} = 3.0 \text{ A} \times 3.0 \Omega$$

$$\Rightarrow V_{3\Omega} = 9.0 \text{ V}$$

- 6 In the circuit diagram, the battery has an internal resistance 1.0Ω which is in series with the 3.0Ω resistor. The EMF of the battery (Σ) is equal to the sum of the potential drops across the internal resistance (V_1) and the 3Ω resistor ($V_{3\Omega}$)

$$\begin{aligned} \Sigma &= V_1 + V_{3\Omega} \\ &= Ir_1 + IR_{3\Omega} \\ &= 3.0 \times 1.0 + 3.0 \times 3.0 \\ &= 3.0 + 9.0 \end{aligned}$$

$$\Rightarrow \Sigma = 12.0 \text{ V}$$

References:

Haber-Schaim, 3rd ed., p. 478.
Ingram, Part 1, pp. 151, 152.
Mayfield, Book 1, pp. 163, 168.
Project Physics, Unit 4, pp. 58, 59.
Williams, p. 418.

- 7 Correct Response: D

Discussion:

Refer to item 3. Using $P = VI$ and substituting

$$I = \frac{V}{R} \text{ from Ohm's law,}$$

$$P = \frac{V^2}{R}$$

$$\Rightarrow P = \frac{12 \text{ V} \times 12 \text{ V}}{2.0}$$

$$\Rightarrow P = 72 \text{ W}$$

References:

Ingram, Part 1, p. 151.
Mayfield, Book 1, p. 173.
Project Physics, Unit 4, pp. 58, 59.
Williams, p. 517.

8 Correct Response: B

Discussion:

The resistance $R(\Omega)$ of a wire of length l (m) and uniform cross-sectional area A (m^2) is given by

$$R = \rho \frac{l}{A} \text{ where } \rho \text{ is a constant called the resistivity.}$$

The value of the resistivity constant depends on the type of material of which the wire is made and its unit is ohm-metre ($\Omega\text{-m}$).

From the information given in the item, ρ and A are constant.

$$\Rightarrow R \propto l (\rho, A \text{ constant})$$

$$\text{Taking ratios } \Rightarrow \frac{R_f}{R_i} = \frac{l_f}{l_i}$$

Since $l_i = 50$ cm, $l_f = 80$ cm, the electrical resistance of the circuit will increase by $\frac{80}{50}$ or $\frac{8}{5}$.

Using Ohm's law, $V = IR$, the battery size V (V) is constant

$$\Rightarrow R \propto \frac{1}{I}$$

$$\text{Taking ratios } \Rightarrow \frac{R_f}{R_i} = \frac{I_i}{I_f}$$

$$\Rightarrow \frac{I_i}{I_f} = \frac{8}{5}$$

$$\Rightarrow \frac{I_f}{I_i} = \frac{5}{8}$$

When the length of conductor is increased from 50 cm to 80 cm, the electrical current will be decreased by a factor of $\frac{5}{8}$

$$\Rightarrow I_f = \frac{5}{8} \times 200 \text{ mA}$$

$$\Rightarrow I_f = 125 \text{ mA}$$

(Alternative B)

References:

Ingram, Part 1, p. 259.

Mayfield, Book 1, pp. 152-155.

Williams, p. 430.

9-11 Correct Responses: 9 C

10 C

11 A

Discussion:

If a light globe is to operate, there must be a complete circuit loop with a source of EMF.

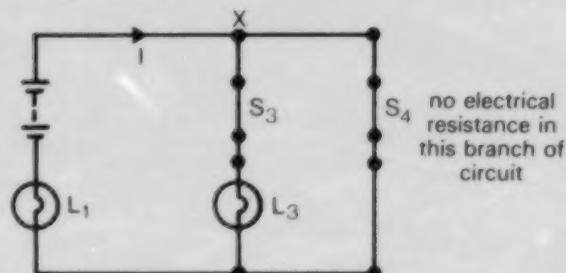
9 When switch S_2 is closed, the complete circuit loop with the battery includes light globes L_1 , L_3 and L_2 .

(Alternative C)

10 When switch S_3 is closed, the complete circuit loop with the battery includes light globes L_1 and L_4 .

(Alternative C)

11 When switches S_3 and S_4 are closed, the circuit network with only the complete circuit loops and the battery becomes:



The circuit branch containing S_3 and L_3 is in parallel with the other branch containing S_4 . Both branches have the same applied potential difference but the branch with S_3 and L_3 will not draw a current. This branch has a resistance due to the filament of globe L_3 while the branch with S_4 has no resistance. When the electrical current I reaches the junction marked X, it will take the 'easier' path via S_4 and return to the battery through globe L_1 . (Alternative A).

References:

Mayfield, Book 1, pp. 168, 169.

Williams, pp. 421-425.

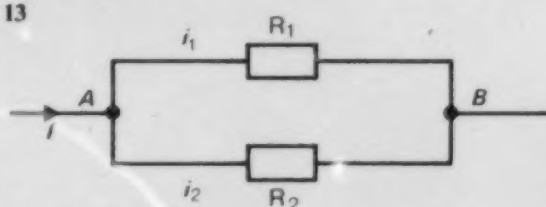
**12 and 13 Correct Responses: 12 D
13 C**

Discussion:

12 For a parallel resistance network, the electrical current into a junction (I) equals the electrical current out of a junction ($i_1 + i_2$)

$$\Rightarrow I = i_1 + i_2$$

13



For a parallel resistance network, the electric potential difference in going from junction A to junction B via resistor R_1 or R_2 is the same. Using $V = IR$ from Ohm's law:

$$\Rightarrow V_1 (\text{across } R_1) = V_2 (\text{across } R_2)$$

$$\Rightarrow i_1 R_1 = i_2 R_2$$

$$\Rightarrow i_1 = i_2 \frac{R_2}{R_1}$$

References:

Haber-Schaim, 3rd ed., p. 478.

Ingram, Part 1, p. 153.

Mayfield, Book 1, p. 168.

- 14-16 Correct Responses: 14 A
15 C
16 B

Discussion:

- 14 The current through the resistor R_2 when the potential difference across it is 5.0 V is found by interpolation from the potential difference (V) versus current (A) graph. The value is 0.33 A.
(Alternative A)

- 15 The slope of the potential difference (V) versus current (A) graph is a measure of electrical resistance (R). Since this graph for R_2 is a straight line through the origin the resistance of R_2 is constant. When the potential difference is 5.0 V, the current is 0.33 A

$$\Rightarrow \text{slope, } R = \frac{\text{rise (5.0 V)}}{\text{run (0.33 A)}}$$

$$\Rightarrow R = \frac{5.0}{\frac{1}{3}}$$

$$\Rightarrow R = 15 \Omega \quad (\text{Alternative C})$$

- 16 The resistors R_1 and R_2 are connected in series with the source of EMF. The EMF of the battery equals the sum of potential differences across R_1 and R_2

$$\Rightarrow \Sigma = V_1 + V_2$$

$$\Rightarrow \Sigma = iR_1 + iR_2$$

$$\Rightarrow \Sigma = i(R_1 + R_2)$$

$$\Rightarrow \frac{\Sigma}{i} = R_1 + R_2$$

$$\Rightarrow \frac{\Sigma}{i} - R_2 = R_1$$

$$\Rightarrow R_1 = \frac{8.0}{0.4} - 15$$

$$\Rightarrow R_1 = 5 \Omega \quad (\text{Alternative B})$$

References:

Haber-Schaim, 3rd ed., pp. 477-482.
Ingram, Part 1, pp. 151, 152.
Mayfield, Book 1, pp. 148-152, 168.
Williams, pp. 422-425.

- 17-21 Correct Responses: 17 C
18 B
19 D
20 A
21 B

Discussion:

- 17 The circuit consists of a battery connected in series with resistors R_1 , R_2 and a parallel combination R_3 and R_4 . A current I (A) through resistors R_1 and R_2 would be split up at the junction of the parallel combination and a current of $\frac{I}{2}$ (A) would pass through R_3 and R_4 since $R_3 = R_4$. Consequently, the smallest current passes through point IV.

(Alternative C).

- 18 The potential difference V between two points is given by the product of current I and the resistance R , that is $V = IR$. The resistance between points III and IV is zero, hence the potential difference is zero.
(Alternative B)

- 19 The sum of the potential differences around the series circuit is equal to the EMF of the battery.

$$\Rightarrow \Sigma = \text{pd across } R_1 + \text{pd across } R_2 + \text{pd across the parallel combination of } R_3 \text{ and } R_4.$$

The potential difference across the battery between points I and V must be greater than that between any other pair of points.
(Alternative D)

- 20 For the original circuit diagram, assuming a current I (A) passes through resistors R_1 and R_2 , a current $\frac{I}{2}$ (A) will pass through resistors R_3 and R_4 (see item 17). The equivalent resistance R_p of this circuit is given by

$$R_E = R_1 + R_2 + \text{equivalent resistance } (R_p) \text{ of the parallel combination } R_3, R_4.$$

For the parallel combination, the equivalent resistance, R_p is given by

$$\frac{1}{R_p} = \frac{1}{R_3} + \frac{1}{R_4}$$

Since $R_3 = R_4 = R_1 = R_2$, let each be of size R

$$\Rightarrow \frac{1}{R_p} = \frac{1}{R} + \frac{1}{R}$$

$$= \frac{2}{R}$$

$$\Rightarrow R_p = \frac{R}{2}$$

For the total circuit, the equivalent resistance R_E will be:

$$R_E = R_1 + R_2 + R_p$$

$$= R + R + \frac{R}{2}$$

$$\Rightarrow R_E = 2.5 R$$

For the modified circuit with resistor R_4 omitted, the equivalent resistance of the series combination R_1 , R_2 and R_3 is given by

$$R_E = R_1 + R_2 + R_3$$

$$= R + R + R$$

$$\Rightarrow R = 3R$$

From $V = IR$, $I \propto \frac{1}{R}$ with the same size battery (V) in each circuit.

$$\Rightarrow \frac{I_2}{I_1} = \frac{R_1}{R_2}$$

where 1 refers to the original circuit, and 2 refers to the modified circuit

$$\text{so } \frac{I_2}{I_1} = \frac{2.5 R}{3 R}$$

$$\Rightarrow \frac{I_2}{I_1} = \frac{5}{6}$$

$$\Rightarrow I_2 = \frac{5}{6} I_1 = \frac{5}{6} I$$

Hence, in the modified circuit the current through R_1 and R_2 has decreased from I to $\frac{5}{6} I$ while the current through R_3 and point IV increased from $\frac{I}{2}$ to $\frac{5}{6} I$. (Alternative A)

- 21 Refer to item 20. The current through points I, II, III and V has decreased from I to $\frac{5}{6} I$. (Alternative B)

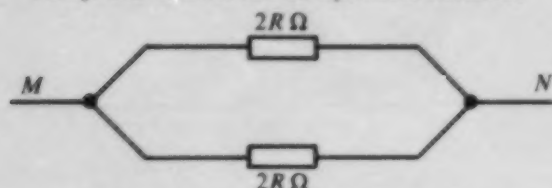
References:

Haber-Schaim, 3rd ed., p. 478;
4th ed., pp. 467-469.
Ingram, Part 1, pp. 151-153.
Mayfield, Book 1, pp. 168, 169.
Project Physics, Unit 4, p. 89.
Williams, pp. 425-427.

- 22 Correct Response: A

Discussion:

The section of circuit illustrated is a parallel circuit with junctions at M and N. The resistors in each arm are joined in series and an equivalent circuit is:



The equivalent resistance of this parallel circuit is given by

$$\begin{aligned} \frac{1}{R_E} &= \frac{1}{R_1} + \frac{1}{R_2} \\ &= \frac{1}{2R} + \frac{1}{2R} \\ &= \frac{2}{2R} \end{aligned}$$

$$\Rightarrow \frac{1}{R_E} = \frac{1}{R}$$

$$\Rightarrow R_E = R$$

The original circuit has an equivalent resistance of $R \Omega$. Hence alternative A is the correct response.

References:

Ingram, Part 1, p. 153.
Mayfield, Book 1, p. 168.
Williams, pp. 421-425.

- 23-25 Correct Responses: 23 A

24 D

25 C

Discussion:

The principle of the potentiometer is to balance the EMF of a cell (E_s and E_u) with the potential difference across a given length of wire XZ. When there is no galvanometer deflection, the cell (E_s and then E_u) draws no current and the same current passes through XY.

$$\Rightarrow E_{\text{cell}} = \text{potential difference across XZ}$$

Point X has the same potential as the positive terminal and point Z has the same potential as the negative terminal of the cell (E_s or E_u) which is connected.

$$\Rightarrow E_{\text{cell}} = IR_{\text{XZ}}, \text{ where } R_{\text{XZ}} \text{ is the resistance of length XZ.}$$

Now resistance R is proportional to the length of wire l (see item 8)

$$\text{that is, } R \propto l \text{ (}\rho, A \text{ constant)}$$

$$\Rightarrow E \propto l_{\text{XZ}} \text{ since } I \text{ is constant}$$

For the standard cell,

$$E_s \propto l_s, \text{ where } l_s \text{ is the length XZ for the standard cell.}$$

For the unknown cell,

$$E_u \propto l_u, \text{ where } l_u \text{ is the length XZ for the unknown cell}$$

$$\Rightarrow \frac{E_u}{E_s} = \frac{l_u}{l_s}$$

- 23 The point Z must be located between X and Y when the balance point is obtained for a particular cell (E_s or E_u). The potential difference across XZ is necessarily less than the potential difference across XY which has a value E_s . Since the potential difference across XZ equals E_u and then E_u , it follows that E_u must be greater than both E_s (Case I) and E_s (Case IV). (Alternative A).

- 24 It has been shown that

$$\frac{E_u}{E_s} = \frac{l_u}{l_s}$$

$$\text{Now } \frac{l_s}{l_u} = \frac{4}{1}$$

$$\Rightarrow \frac{E_u}{E_s} = \frac{l_u}{l_s} = \frac{4}{1}$$

- 25 The information given is that $E_s = 1.25 \text{ V}$, $l_s = 26 \text{ cm}$ and $l_u = 52 \text{ cm}$.

Using

$$\frac{E_u}{E_s} = \frac{l_u}{l_s}$$

$$\Rightarrow E_u = \frac{l_u}{l_s} \times E_s$$

$$= \frac{52 \text{ cm}}{26 \text{ cm}} \times 1.25 \text{ V}$$

$$= 2 \times 1.25 \text{ V}$$

$$\Rightarrow E_u = 2.50 \text{ V}$$

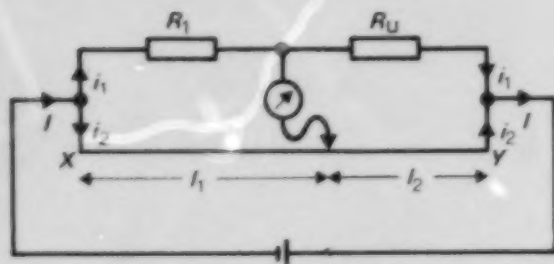
References:

Ingram, Part 1, pp. 261–263.
Mayfield, Book 1, pp. 165–167.

26 and 27 Correct Responses: 26 D
27 B

Discussion:

26



The slide wire bridge circuit is effectively a parallel circuit network. Assume that a current I enters the junction and a current i_1 passes through R_1 and R_u and a current i_2 passes through XY when the galvanometer is undeflected, that is at balance point. The potential difference across resistance R_1 is equal to the potential difference across the length of wire l_1

$$\begin{aligned} \Rightarrow V(\text{across } R_1) &= V(\text{across } l_1) \\ \Rightarrow i_1 R_1 &= i_2 R_{l_1} \\ \Rightarrow \frac{i_1}{i_2} &= \frac{R_{l_1}}{R_1} \end{aligned} \quad \dots (1)$$

Similarly, the potential difference across the unknown resistance R_u is equal to the potential difference across the length of wire l_2

$$\begin{aligned} \Rightarrow V(\text{across } R_u) &= V(\text{across } l_2) \\ \Rightarrow i_1 R_u &= i_2 R_{l_2} \\ \Rightarrow \frac{i_1}{i_2} &= \frac{R_{l_2}}{R_u} \end{aligned} \quad \dots (2)$$

From equations (1) and (2),

$$\begin{aligned} \frac{R_{l_1}}{R_1} &= \frac{R_{l_2}}{R_u} \\ \Rightarrow \frac{R_u}{R_1} &= \frac{R_{l_2}}{R_{l_1}} \end{aligned}$$

Now the resistance R is proportional to the length l of the wire (see item 8)

$$\Rightarrow R \propto l \quad (\rho, A \text{ constant})$$

$$\Rightarrow \frac{R_u}{R_1} = \frac{l_2}{l_1}$$

hence,

$$\frac{R_u}{R_1} = \frac{l_2}{l_1}$$

$$\Rightarrow R_u = \frac{l_2}{l_1} \cdot R_1 \quad (\text{Alternative D})$$

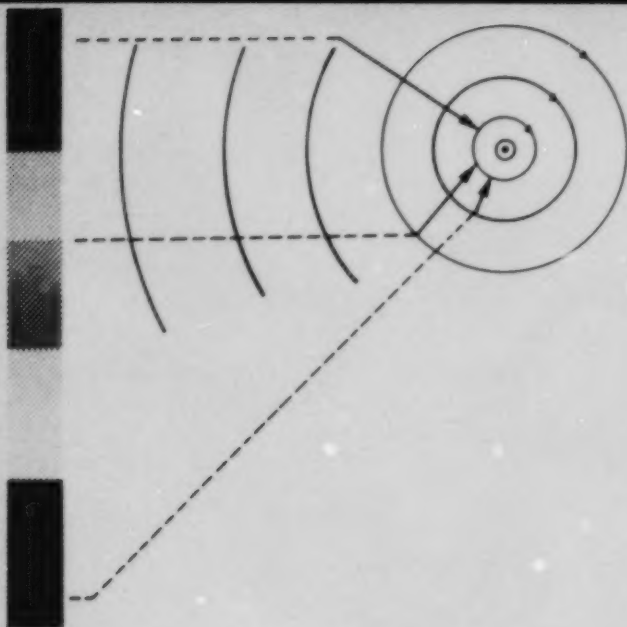
27 The information given is that $R_1 = 12 \Omega$, $l_1 = 60 \text{ cm}$ and $l_2 = 40 \text{ cm}$.

Using

$$\begin{aligned} R_u &= \frac{l_2}{l_1} \cdot R_1 \\ \Rightarrow R_u &= \frac{40}{60} \times 12 \\ \Rightarrow R_u &= 8 \Omega \end{aligned}$$

References:

Ingram, Part 1, pp. 257–259.
Mayfield, Book 1, p. 171.
Williams, pp. 433, 434.



Diagnostic Aid 18 The magnetic field

Description

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In each diagnostic aid an explanation is provided so that the reasons why the responses are correct or incorrect are available to you.

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1 Correct Response: A

Discussion:

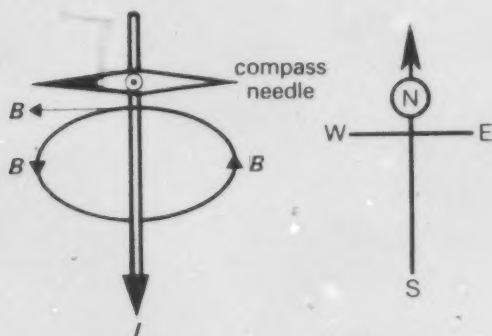
The direction and orientation of magnetic field lines are determined by the right hand screw rule provided that the current is conventional current.

References:

Haber-Schaim, 3rd ed., p. 495.
Ingram, Part 1, pp. 172-174.
Mayfield, Book 1, p. 103.
Williams, p. 473.

2 Correct Response: C

Discussion:



If a large conventional current is flowing from north to south, then circular magnetic lines of force (B) will be set up around the wire in a direction given by the right hand screw rule (see diagram). At any given point on these circular field lines, the direction of the magnetic line of force will be along the tangent to the circular path of the field and it is along this tangent that a compass needle will align itself. Hence, if a compass needle is placed directly above our current carrying wire then the north-seeking pole of the needle will point to the west.

References:

Haber-Schaim, 3rd ed., pp. 490-492.
Ingram, Part 1, pp. 172-174.
Mayfield, Book 1, p. 103.
Williams, pp. 473-474.

3 Correct Response: B

Discussion:

Magnetic field is a vector quantity so it is necessary to perform a vector addition of the field strengths due to magnets Y and Z at point P. Because the polarity of the two magnets have not been given, directions for the two field strengths must be arbitrarily assigned in order to perform the vector addition.

Now, let the magnetic field at P due to magnet Y be $\vec{B}_y$ and that due to magnet Z be $\vec{B}_z$. Point P is equidistant from the two magnets,

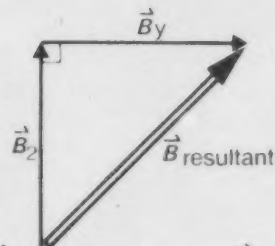
$$\text{hence, } |\vec{B}_y| = |\vec{B}_z|$$

$$\text{that is, } B_y = B_z = B$$

$$B_{\text{resultant}}^2 = B_y^2 + B_z^2$$

$$\Rightarrow B_{\text{resultant}}^2 = 2B^2$$

$$\Rightarrow B_{\text{resultant}} = \sqrt{2} B$$



Note that because $\vec{B}_y$ is perpendicular to $\vec{B}_z$ and equal in magnitude, $B_{\text{resultant}} = \sqrt{2} B$ no matter what direction $\vec{B}_y$ and $\vec{B}_z$ are assigned to. Hence, it is not necessary to know the polarity of the two magnets in this case.

References:

Haber-Schaim, 3rd ed., pp. 495-497.
Ingram, Part 1, pp. 174, 175.
Mayfield, Book 1, p. 102.

4 Correct Response: D

Discussion:

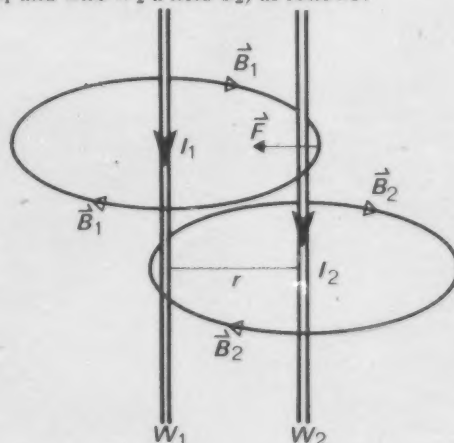
The Biot-Savart relationship between magnetic field strength B , the current I flowing in a long straight wire and the distance from the wire r , is given by:

$$B_{\text{ST WIRE}} = K \frac{I}{r} \quad \text{where } K \text{ is}$$

the constant of proportionality.

$$\text{Hence, } B_{\text{ST WIRE}} \propto \frac{I}{r}$$

If there are two such current carrying wires (W_1 and W_2) set up parallel to each other, then each wire will produce a magnetic field in the vicinity of the other wire (wire W_1 will produce a field $\vec{B}_1$ and wire W_2 a field $\vec{B}_2$) as follows:



Now consider wire 2: it will experience a force $\vec{F}$ due to field $\vec{B}_1$ and the magnitude of this force will be given by: $F = I_2 l B_1$, where l is the length of the wire W_2 influenced by $\vec{B}_1$ and will be constant in this case. If B_1 is replaced in this expression by the Biot-Savart expression for B (due to wire W_1) then:

$$F = I_2 l \frac{KI_1}{r}$$

$$\Rightarrow F = \frac{KI_1 I_2 l}{r}$$

However, K , I_1 , I_2 and l are all constant in this case,

$$\Rightarrow F = \frac{\text{constant}}{r}$$

$$\Rightarrow F \propto \frac{1}{r}$$

Similarly, wire 1 will experience a force of magnitude F due to field $\vec{B}_2$ produced by wire 2, and the force on each wire will have the same magnitude.

Hence, in order to reduce the force between these two wires by half, the expression $F \propto \frac{1}{r}$ shows that it will be necessary for r to be double its previous value.

(Alternative D)

References:

Haber-Schaim, 3rd ed., pp. 495-497.
Ingram, Part 1, pp. 162-167.
Mayfield, Book 1, pp. 105-107.
Project Physics, Unit 4, pp. 162, 163.
Williams, pp. 472, 473.

5 Correct Response: A

Discussion:

If a force acts at right angles to the direction of motion of a particle then the component of the force in the direction of motion will be zero and hence no change in speed of the particle will take place. (Alternative A). However, such a force will continuously change the direction of the particle's motion and in order for the force to stay at right angles to the direction of motion, the particle must move in a circular path, that is, the force is acting as a centripetal force.

References:

Haber-Schaim, 3rd ed., p. 504.
Ingram, Part 1, pp. 180-183.
Mayfield, Book 1, pp. 136-139.
Project Physics, Unit 4, pp. 66-68.
Williams, p. 490.

6 Correct Response: A

Discussion:

The magnitude of the force F acting on a length l of wire carrying a current I in the presence of a magnetic field which is perpendicular to the current and of strength $B_\perp$, is given by the relation: $F = IlB_\perp$.

In this case, $B_\perp = 4 \times 10^{-2}$ tesla

$$F = 4 \times 10^{-2} \text{ Newton}$$

$$l = 0.1 \text{ metre}$$

substituting for l gives,

$$I = \frac{F}{lB_\perp}$$

$$= \frac{4 \times 10^{-2}}{0.1 \times 4 \times 10^{-2}} \text{ ampere}$$

$$= 10 \text{ ampere}$$

References:

Haber-Schaim, 3rd ed., pp. 498-500.
Ingram, Part 1, pp. 167-170.
Mayfield, Book 1, pp. 108, 109.
Project Physics, Unit 4, pp. 147-153.

7 Correct Response: C

Discussion:

A charge moving in a magnetic field will only experience a force if the magnetic field has a component which is perpendicular to the direction of motion of the particle. Hence, any particle moving in a direction which is parallel to the magnetic field will experience no force due to this field.

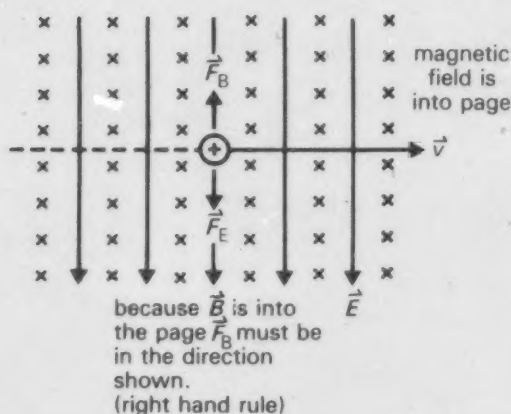
References:

Haber-Schaim, 3rd ed., pp. 502-505.
Ingram, Part 1, pp. 180-183.
Mayfield, Book 1, pp. 136-138.
Project Physics, Unit 4, p. 67.
Williams, p. 490.

8 Correct Response: B

Discussion:

If the charges move through the magnetic and electric fields undeflected, then the force on them due to the magnetic field $\vec{F}_B$ must be equal but opposite in direction to the force on them due to the electric field $\vec{F}_E$.



The magnitude of the electric force on a charge q is given by $F_E = qE$, where E is the magnitude of the electric field. The magnitude of the force due to a magnetic field of strength B is given by $F_B = qvB$, where v is the speed of the particle moving through the field.

Hence, $F_E = F_B$ if the particle is undeflected.

$$\Rightarrow qE = qvB$$

$$\Rightarrow v = \frac{E}{B}$$

Here $E = 5 \times 10^4 \text{ V m}^{-1}$ and $B = 2 \times 10^{-3} \text{ tesla}$

$$\Rightarrow v = \frac{5 \times 10^4}{2 \times 10^{-3}} \text{ m s}^{-1}$$

$$\Rightarrow v = 2.5 \times 10^7 \text{ m s}^{-1}$$

References:

Haber-Schaim, 3rd ed., pp. 508, 509.
Ingram, Part 1, p. 186.
Mayfield, Book 1, pp. 136–138.

9 Correct Response: D

Discussion:

Using the right hand screw rule shows that the current in conductor X must be directed 'out of the page' and the current in conductor Y must be directed 'into the page'. Also, because there are far more magnetic field lines per unit area surrounding conductor Y then the field due to current Y must be much stronger.

(Alternative D)

References:

Haber-Schaim, 3rd ed., pp. 491–495.
Ingram, Part 1, pp. 173, 174.
Mayfield, Book 1, pp. 108, 109, 164, 167.
Project Physics, Unit 4, pp. 147–151.
Williams, pp. 472, 473.

10 Correct Response: C

Discussion:

The strength of the magnetic field $B_{\text{ST WIRE}}$ at a distance r from a long straight conductor carrying a current I is given by the Biot-Savart relationship

$$B_{\text{ST WIRE}} = \frac{KI}{r}$$

where K is the constant of proportionality

$$\Rightarrow B_{\text{ST WIRE}} \propto \frac{1}{r}$$

Here, the distance r is increased from 0.05 m to 0.15 m, that is r has been increased by a factor of 3.

This means, since $B \propto \frac{1}{r}$, that B will decrease by a factor of $\frac{1}{3}$, so,

$$\begin{aligned} B(\text{at } 0.15 \text{ m}) &= \frac{1}{3} \times 3 \times 10^{-6} \text{ tesla} \\ &= 1 \times 10^{-6} \text{ tesla} \end{aligned}$$

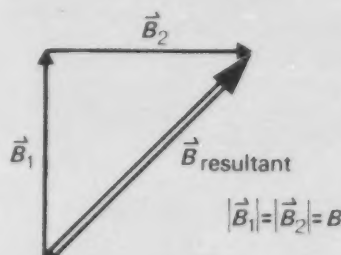
References:

Haber-Schaim, 3rd ed., pp. 509, 510.
Ingram, Part 1, pp. 164–167.
Mayfield, Book 1, pp. 108, 109.
Project Physics, Unit 4, pp. 147–151.
Williams, p. 474.

11 Correct Response: B

Discussion:

Since magnetic field is a vector quantity it is necessary to use vector addition for $\vec{B}_1$ and $\vec{B}_2$. Hence the resultant field is found as shown in the diagram:



From Pythagoras' theorem:

$$B_{\text{resultant}}^2 = B_1^2 + B_2^2$$

$$\Rightarrow B_{\text{resultant}}^2 = 2B^2$$

$$\Rightarrow B_{\text{resultant}} = \sqrt{2} B$$

Each of the original loops carried a current of 2 ampere and each produced a field of strength B . So our single loop which is to replace them will need to carry a current of $\sqrt{2} \times (2 \text{ ampere})$ in order to produce a field of strength $\sqrt{2} B$.
(Alternative B)

References:

Haber-Schaim, 3rd ed., pp. 495-497.
Ingram, Part 1, p. 173.
Mayfield, Book 1, p. 110.

12 Correct Response: D

Discussion:

The electric charge would experience no magnetic force if placed at P . An electric charge must be moving and in a direction which is not parallel to the magnetic field in order to experience a magnetic force ($F = qvB_{\perp}$).

References:

Haber-Schaim, 3rd ed., pp. 502-505.
Ingram, Part 1, pp. 180-183.
Mayfield, Book 1, pp. 136-139.
Project Physics, Unit 4, pp. 66-68.
Williams, p. 490.

13 Correct Response: A

Discussion:

A uniform magnetic field will deflect electrons into a circular path providing the electrons enter the field in a direction which is perpendicular to the field. This occurs because the force on the electrons, due to the magnetic field, will always be acting at right angles to the direction of motion of the electrons, that is, the force will be a centripetal one and will cause the electrons to move in a circular path with constant speed.

References:

Haber-Schaim, 3rd ed., p. 504.
Ingram, Part 1, pp. 180-183.
Mayfield, Book 1, pp. 136-139.
Project Physics, Unit 4, pp. 66-68.
Williams, p. 490.

14-17 Correct Responses: 14 B

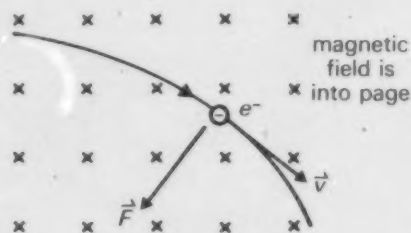
15 A

16 B

17 A

Discussion:

Since the charged particle is moving at right angles to the field, it will move along a circular path with the magnetic force $\vec{F}$ acting as a centripetal force, as shown in the diagram.



Using the right hand rule (remembering that $\vec{B}$ is into the page) it can be seen that positive charge would flow in the opposite direction to that shown on the path. This means that the charge on the given particle must be negative.

(Alternative B)

- 15** The charges will move with speed v in a circular path of radius r due to the magnetic force contributing the centripetal force of the motion. Hence,

$$F_{\text{magnetic}} = F_{\text{centripetal}} \\ \Rightarrow qvB = \frac{mv^2}{r}$$

where q is the charge on the particle and m is its mass

$$\Rightarrow mv = qrB$$

In this case q , v and B are all held constant,

$$\text{so } r \propto m$$

Thus, if a particle of smaller mass enters the field with the same speed, then r must be less and the path will be deflected towards I.

- 16** Now, $mv = qrB$ (see item 15). Here, m , q and B are constant,

$$\text{so } r \propto v$$

The path of such a particle will have a greater radius if v is greater which means the path will be deflected towards III.

- 17 Using the same expression $mv = q r B$ (see item 15) and holding m , v and q constant, it can be seen that

$$B \propto \frac{1}{r}$$

So, if B is increased, then r must decrease which means the path will be deflected towards I.

References:

Haber-Schaim, 3rd ed., pp. 502–505.
Ingram, Part 1, pp. 180–183.
Mayfield, Book 1, pp. 136–139.
Project Physics, Unit 4, pp. 66–68.
Williams, p. 490.

18 Correct Response: D

Discussion:

Using the right hand rule for positive charge flow, the direction of the force due to the magnetic field will be 'into the page' which is direction $-Z$ in the given frame of reference.

References:

Haber-Schaim, 3rd ed., p. 499.
Ingram, Part 1, p. 170.
Mayfield, Book 1, p. 109.
Project Physics, Unit 4, pp. 66–68, 152, 153, 157, 158.
Williams, p. 494.

19 Correct Response: D

Discussion:

In order to determine the magnetic field strength necessary to produce a given force on a given length of conductor, it is necessary to have information about the current flowing in the conductor. The relationship $F = I l B_{\perp}$ can then be used.

$$\Rightarrow B_{\perp} = \frac{F}{Il}$$

In this case, the values of F and l are given, but there is no information concerning I .

(Alternative D)

References:

Haber-Schaim, 3rd ed., pp. 497–500.
Ingram, Part 1, pp. 167, 168.
Mayfield, Book 1, p. 109.
Project Physics, Unit 4, pp. 152, 153.

20 Correct Response: D

Discussion:

For a charged particle to experience a force while in the presence of a magnetic field, it must be moving in a direction such that there is a component of the magnetic field at right angles to the direction of motion of the charge. In this example, the charge is moving parallel to the field so that the component of the field at right angles to the direction of motion of the charge is zero. Hence the charge will experience zero force.

(Alternative D)

References:

Haber-Schaim, 3rd ed., p. 494.
Ingram, Part 1, pp. 180–183.
Mayfield, Book 1, p. 138.
Project Physics, Unit 4, pp. 66–68.
Williams, pp. 474, 475.

21 Correct Response: B

Discussion:

As the conductor moves in the direction $-y$, a 'current' will be induced along the conductor causing a magnetic force $\vec{F}$ to be set up in direction y to oppose the motion. If this did not happen energy could not be conserved in such situations.

By applying the right hand rule, where $\vec{B}$ is in direction $-Z$ and $\vec{F}$ is in direction y , the conventional current must be in direction x . This means that the negatively charged particles will tend to move in direction $-x$.

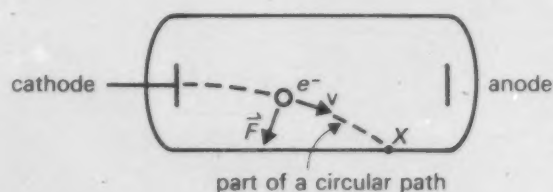
References:

Haber-Schaim, 3rd ed., pp. 531, 532.
Ingram, Part 1, pp. 186–189.
Mayfield, Book 1, pp. 182–185.
Project Physics, Unit 4, pp. 66–68.
Williams, p. 490.

22 Correct Response: C

Discussion:

An electron moving at right angles to a uniform magnetic field will travel with speed v along a circular path from the cathode to X due to the magnetic force $\vec{F}$ acting as a centripetal force.



This would be exactly equivalent to a positive charge moving from X to the cathode. Applying the right hand rule for this positive charge reveals that the magnetic field must be directed 'into the page', that is, in direction $-z$.

(Alternative C)

References:

Haber-Schaim, 3rd ed., pp. 502–505.
Ingram, Part 1, pp. 180–183.
Mayfield, Book 1, pp. 136–139.
Project Physics, Unit 4, pp. 66–68.
Williams, p. 490.

- 23-25 Correct Responses: 23 C
24 D
25 C

Discussion:

- 23 By the right hand screw rule, the direction of the magnetic field at S due to Q is in direction z . Similarly, the field at S due to P is in direction z . Thus both fields add vectorially to give a resultant field in direction z .
- 24 At R the field due to Q will be in direction $-z$ while the field due to P will be in direction $+z$. Since R is equidistant from P and Q and since equal currents flow in P and Q then the two field vectors at R will add to give a zero vector. That is, the resultant field at R will be zero.
- 25 The current in P (call this I_p) = 30 A and the current in Q (call this I_q) = 5 A.
Point S is 0.3 m from wire P and so by using the Biot-Savart relation, namely:

$$B = \frac{KI}{r} \quad \text{where } K = 2 \times 10^{-7} \text{ N A}^{-2}$$

the magnitude of the field at S due to wire P (call this B_p) can be obtained as follows:

$$\begin{aligned} B_p &= \frac{KI_p}{r_p} \\ &= \frac{2 \times 10^{-7} \times 30}{3 \times 10^{-1}} \text{ tesla} \\ &= 2 \times 10^{-5} \text{ tesla} \end{aligned}$$

Similarly, the magnitude of the field at S due to the wire Q (call this B_q) will be given by:

$$\begin{aligned} B_q &= \frac{K \cdot I_q}{r_q} \\ &= \frac{2 \times 10^{-7} \times 5}{1 \times 10^{-1}} \text{ tesla} \\ &= 1 \times 10^{-5} \text{ tesla} \end{aligned}$$

It has already been shown in item 23 that the fields due to both P and Q at S are in the same direction, that is z , so the resultant field strength at S will have a magnitude given by the sum

$$B_p + B_q = 3 \times 10^{-5} \text{ tesla.}$$

References:

Haber-Schaim, 3rd ed., pp. 509, 510.
Ingram, Part 1, pp. 164-167.
Mayfield, Book 1, pp. 108, 109.
Project Physics, Unit 4, pp. 62, 63, 147-151.
Williams, pp. 472, 473.

ACER PHYSICS UNIT TESTS

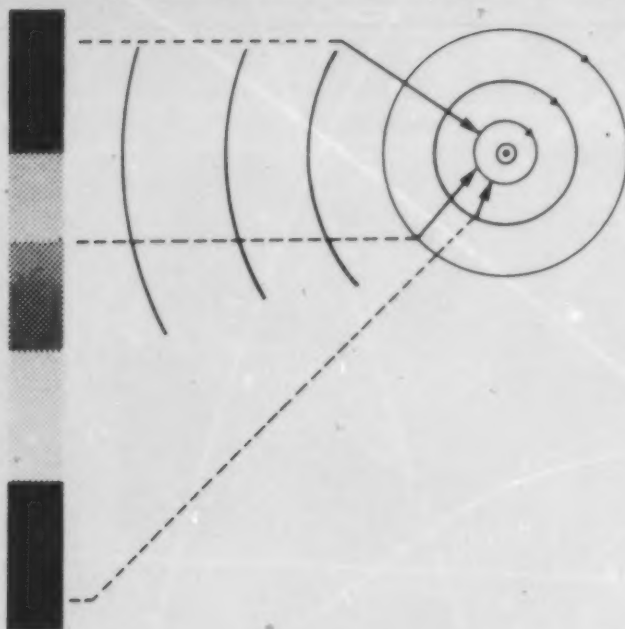
The ACER Physics Unit Tests consist of the following publications.

I A collection of tests covering the following topics

- 1 *Physical measurement*
- 2 *Vectors*
- 3 *Motion in one dimension*
- 4 *Motion on a plane*
- 5 *Dynamics*
- 6 *Work and energy*
- 7 *Linear momentum*
- 8 *Oscillations*
- 9 *Gravity and Kepler's laws*
- 10 *Waves*
- 11 *Light — reflection and refraction*
- 12 *Light — interference, diffraction and spectra*
- 13 *Models of light*
- 14 *Kinetic theory of gases*
- 15 *Static charges*
- 16 *Electric field and potential difference*
- 17 *Current electricity*
- 18 *The magnetic field*
- 19 *Induced EMF*
- 20 *Atomic physics*
- 21 *Quantum physics*

II A collection of 21 Diagnostic Aids covering topics corresponding to the tests.

III Teachers Handbook



Diagnostic Aid 19 Induced EMF

Description

This diagnostic aid is one of a collection of 21 diagnostic aids corresponding to the 21 separate tests in the *Physics Unit Tests*.

In each diagnostic aid an explanation is provided so that the reasons why the responses are correct or incorrect are available to you.

To gain maximum benefit from the *Physics Unit Tests* weaknesses diagnosed need to be followed up. These diagnostic aids make it possible for you to proceed with this follow up in your own time. If you do not understand the discussion you are advised to seek help from your teacher.

References

The references throughout the Diagnostic Aids have been abbreviated. The abbreviations and full publication details are listed.

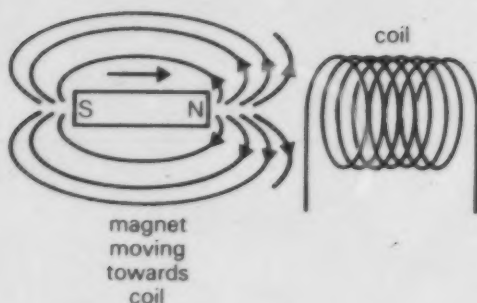
- Haber-Schaim: Haber-Schaim, U., Cross, J.B., Dodge, J.H., and Walter, J.A. *PSSC Physics*. 4th ed. Lexington, Mass.: D.C. Heath, 1976. (Reference is also made to 3rd ed.)
- Ingram: Ingram, A.D., Kuhl, D.H., McCarthy, I.E., Sandercock, E.R., Smith, W.F., and Waite, P.J. *Physics: A Laboratory-oriented Approach*. (Study Guide Leaving Part 1, Study Guide Matriculation Part 2). Adelaide: Rigby, 1971, 1972.
- Mayfield: Mayfield, J.M. Parham, R.T., and Webber, B.J. *Fundamentals of Senior Physics*. (Book 1, Book 2). Melbourne: Heinemann Educational Australia Pty Ltd, 1973.
- Project Physics: *Project Physics Course: Programmed Instruction Books* (Kinetic Molecular Theory of Gases, Waves 1-2, Equations 1-3, Vectors 1-3); *Text and Handbook* (Units 1-6). Sydney: Martin Educational, 1970.
- Williams: Williams, J.E., Trinkle, F.E., Metcalfe, H.C., and Lefler, R.W. *Modern Physics*. New York: Holt, Rinehart, & Winston, 1976.

The Australian Council for Educational Research Limited thanks the following publishers for donating textbooks used in referencing the aids: Heinemann Educational Australia Pty Ltd, Richmond, Victoria, for *Fundamentals of Senior Physics*. Rigby Limited, Box Hill, Victoria, for *Physics: A Laboratory-oriented Approach*.

Do not write on this booklet

1 Correct Response: B

Discussion:



The size of the EMF ($\mathcal{E}$) induced in the coil will be given by the relationship:

$$\mathcal{E} = \frac{\Delta\phi_B}{\Delta t}$$

where $\Delta\phi_B$ is the change in magnetic flux. The magnetic flux is defined as $\phi_B = BA$ with B being the magnetic field strength threading a given current loop of area A . If our coil above has N turns then the total effective area being threaded by field lines as the magnet approaches the coil will be NA . This will be a constant for a given coil.

Now, as the magnet is moved towards the coil, the number of field lines threading the loop will increase and so there will be a change in flux inside the coil given by: $\Delta\phi_B = NA(\Delta B)$. The faster the magnet moves, the greater the value of ΔB and the larger the change in flux.

$$\text{So, } \mathcal{E} = \frac{\Delta\phi_B}{\Delta t} = \frac{NA(\Delta B)}{\Delta t}$$

which means that the EMF will depend on N and the speed with which the magnet is moved.

Note that the EMF expression makes no mention of either temperature or resistivity of the wire in the coil. The resistivity will not affect the EMF produced but it will affect the size of the current induced, because $\mathcal{E} = IR$.

If $\mathcal{E}$ is fixed by a given coil and speed of movement of the magnet, then

$$\mathcal{E} = IR \quad (\mathcal{E} \text{ constant})$$

$$\Rightarrow I \propto \frac{1}{R}$$

and so as R increases, I will decrease, that is, less current will flow.

Also, because the temperature has an indirect effect on resistance, then as the temperature changes so will R and hence I will be affected but neither resistivity nor temperature will affect the size of the EMF ($\mathcal{E}$) which will be induced.

References:

- Haber-Schaim, 3rd ed., pp. 531-532.
Ingram, Part 1, pp. 189-192.
Mayfield, Book 1, pp. 154-157, 180-185.
Project Physics, Unit 4, pp. 77-81.
Williams, p. 487.

2-4 Correct Responses: 2 C

3 B

4 A

Discussion:

- 2 Each turn of the coil has an area of $3.0 \times 10^{-2} \text{ m}^2$ and the magnetic field strength threading each turn decreases from 6.0×10^{-4} tesla to zero in 1.0×10^{-2} seconds. So the change in magnetic flux in each loop (ϕ_B) will be given by,

$$\Delta\phi_B = A(\Delta B)$$

$$\approx 3.0 \times 10^{-2} \times (0.0 - 6.0 \times 10^{-4}) \text{ weber}$$

$$= -1.8 \times 10^{-5} \text{ weber}$$

The minus sign gives information on the direction of the flux change. Here, only the size of the EMF is required and not its direction so the sign is disregarded.

The EMF induced in each loop will be given by the expression:

$$\mathcal{E} = \frac{\Delta\phi_B}{\Delta t}$$

$$= \frac{A(\Delta B)}{\Delta t}$$

$$= \frac{1.8 \times 10^{-5}}{1.0 \times 10^{-2}} \text{ volts}$$

$$= 1.8 \times 10^{-3} \text{ volts.}$$

However, there are 20 turns of wire in the coil and if each turn has an EMF ($\mathcal{E}$) of 1.8×10^{-3} volts induced in it, the total EMF induced in the coil ($\mathcal{E}_{\text{tot}}$) will be given by,

$$\mathcal{E}_{\text{tot}} = 20 \times \mathcal{E}$$

$$= 20 \times 1.8 \times 10^{-3} \text{ volts}$$

$$\Rightarrow \mathcal{E}_{\text{tot}} = 3.6 \times 10^{-2} \text{ volts}$$

(Alternative C)

- 3 The magnetic flux (ϕ_B) is given by,

$$\phi_B = B \cdot A$$

and in this case a change in the flux ($\Delta\phi_B$) threading the loop is brought about by an increase in field strength B from a value of 6.0×10^{-4} tesla to a value of 1.0×10^{-3} tesla while the area of the loop remains unchanged at a value of $3.0 \times 10^{-2} \text{ m}^2$. Thus,

$$\begin{aligned}\Delta\phi_B &= A \cdot (\Delta B) \\ &= 3.0 \times 10^{-2} \times (1.0 \times 10^{-4} \\ &\quad - 6.0 \times 10^{-4}) \text{ weber} \\ &= 3.0 \times 4.0 \times 10^{-6} \text{ weber} \\ &= 1.2 \times 10^{-5} \text{ weber}\end{aligned}$$

Note that no information is needed concerning time in order to determine the flux change here. Information about the time would be needed if it was required to find the EMF induced.

- 4 To answer this item it is necessary to apply Lenz's law which states that when the magnetic flux changes inside a closed loop, the EMF induced in the loop is such as to produce a current which will oppose the flux change. If this were not so, energy could not be conserved in such situations.

In this example, the magnetic field (and hence the flux) is 'into the page' and is decreasing and finally becomes zero. As this happens Lenz's law implies that a current will be induced in the loop in such a direction as to produce its own flux 'into the page' to oppose the decrease. Applying the right hand screw rule shows that a current necessary to achieve this must be in a clockwise direction around the loop.

References:

Haber-Schaim, 3rd ed., pp. 525-532.
Ingram, Part 1, pp. 189-193.
Mayfield, Book 1, pp. 180-185.
Williams, pp. 487, 488, 490, 491.

- 5 and 6 Correct Responses: 5 A
8 D

Discussion:

- 5 When a conductor of length l moves at speed v perpendicular to a magnetic field of strength B , the EMF ($\mathcal{E}$) induced in the conductor is given by the relation

$$\mathcal{E} = B l v$$

In this example, $l = \text{length } YZ = 2 \times 10^{-2} \text{ m}$

$$B = 3 \times 10^{-2} \text{ tesla}$$

$$v = 4 \times 10^{-1} \text{ m s}^{-1}$$

so, $\mathcal{E} = B l v$

$$= 3 \times 10^{-2} \times 2 \times 10^{-2} \times 4 \times 10^{-1} \text{ volts}$$

$$= 2.4 \times 10^{-4} \text{ volts}$$

- 6 When an EMF ($\mathcal{E}$) is applied across a uniform wire of length l , an electric field ($\vec{E}$) is set up along the wire and its magnitude (E) can be found by using the expression:

$$\mathcal{E} = E \cdot l$$

In this case, $l = 2 \times 10^{-2}$

$$\Rightarrow E = \frac{\mathcal{E}}{l}$$

where $\mathcal{E} = 2.4 \times 10^{-4}$ volts (see item 5)

$$\begin{aligned}\text{so, } E &= \frac{\mathcal{E}}{2 \times 10^{-2}} \text{ volts m}^{-1} \\ &= 50 \mathcal{E} \text{ volts m}^{-1}.\end{aligned}$$

References:

Haber-Schaim, 3rd ed., pp. 470-472, 531, 532.
Ingram, Part 1, pp. 186-189.
Mayfield, Book 1, pp. 182, 183.
Williams, p. 489.

- 7 and 8 Correct Responses: 7 D
8 B

Discussion:

- 7 In order to induce an EMF in such a loop there must be a change in flux inside the loop. Because the plane of the loop in this example is always perpendicular to the magnetic field, the flux will be given by,

$$\phi_B = B \cdot A$$

where B is the magnetic field strength and A is the area of the loop which will be constant in this case. Hence a change in flux will depend on a change in magnetic field strength,

$$\text{that is, } \Delta\phi_B = A \cdot (\Delta B)$$

Now, consider each of the four cases in the problem:

Case I: The field strength will change here because as the loop moves into the field, more and more field lines thread it. This means a change in flux will occur resulting in an EMF being induced.

Case II: Because the loop is completely enclosed in a uniform field, there will be no change in the number of field lines threading it until it reaches the edge of the field and becomes similar to Case I. Hence $\Delta B = 0$ in this case and so no EMF will be induced.

Case III: The case is similar to Case I except that as the loop leaves the field less and less field lines will thread it which means a change in flux. However, the direction of the EMF will be opposite to that of case I.

Case IV: Because the loop is completely enclosed in the field and the field is uniform, no matter what the position of the loop, it will still have the same number of field lines threading it. Hence the change in field will be zero and so no EMF will be induced.

However, it is important to realise that if the loop in case IV had been rotating about an axis which is perpendicular to the field rather than one which is parallel to the field, then the effective area exposed to field lines would change and hence an EMF would result.

- 8 The only two cases in which a current will be induced are cases I and III (see item 7). To determine the direction of the EMF induced, it is necessary to apply Lenz's law (see item 4).

Now, in Case I, as the loop moves into the field there is an increase in the number of field lines threading the loop, that is, the flux threading the loop is increasing ('into the page'). Hence, by Lenz's law, the EMF induced around the loop must be such as to produce an increasing flux 'out of the page'. Applying the right hand screw rule shows that the direction of this EMF must be such as to produce a conventional current in an anti-clockwise direction around the loop.

In Case III, as the loop moves out of the field, there will be a decrease in the number of field lines threading it, that is, the flux threading the loop is decreasing ('into the page'). Hence Lenz's law shows that the EMF induced must be such as to produce an increase of flux threading the loop ('into the page'). The right hand screw rule shows that the direction of this EMF must be such as to produce a conventional current in a clockwise direction around the loop.

References:

- Haber-Schaim, 3rd ed., pp. 525-531.
Ingram, Part I, pp. 186-189.
Mayfield, Book 1, pp. 182-185.
Williams, pp. 464, 490.

9-11 Correct Responses: 9 D

10 A

11 A

Discussion:

- 9 Because the frequency (f) of rotation of the loop is constant, then points P and Q will each move in circular paths at constant speed (see diagram).



The radii of these circular paths will be $\frac{y}{2}$ and so their circumference will be of magnitude

$$C = 2\pi \frac{y}{2} = \pi y$$

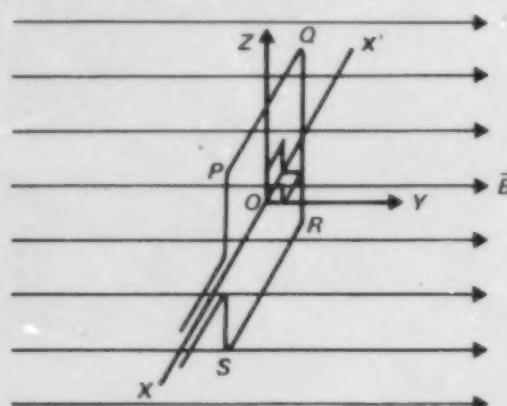
Hence the speed of points P and Q will be given by $v = \frac{C}{T}$, where T is the period of rotation and $T = \frac{1}{f}$

$$\Rightarrow v = cf$$

$$\Rightarrow v = \pi y f$$

which will also be the speed of side PQ .

10



At this instant the amount of flux threading the loop is maximum but the rate of change of this flux is zero, that is, the sides PQ and RS are not 'cutting' any field lines and so the induced EMF will be zero.

Note that the rate of change of flux (and therefore the EMF induced) will be a maximum when the plane of the loop is parallel to the plane of the field.

- 11 If the whole loop were moved (while still horizontal) in the direction OZ , then at no point throughout the motion would the loop be able to be threaded by field lines because it would be parallel to the field, that is no flux change could take place because the effective area which is perpendicular to the field would be zero.

$$\text{So } \Delta\phi_B = B \cdot \Delta A \quad (B \text{ is constant})$$

$$\text{and } \Delta A = 0$$

$$\Rightarrow \Delta\phi_B = 0$$

$$\Rightarrow \varepsilon = \frac{\Delta\phi_B}{\Delta t} = 0$$

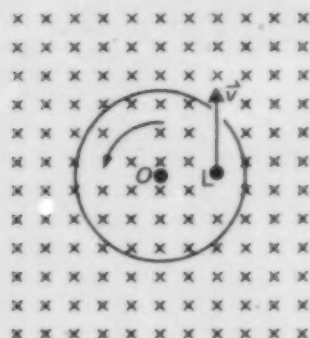
(Alternative A.)

References:

Haber-Schaim, 3rd ed., pp. 529–531.
Ingram, Part 1, pp. 195, 196.
Mayfield, Book 1, p. 186.
Project Physics, Unit 4, pp. 81–84.
Williams, p. 495.

- 12 **Correct Response: C**

Discussion:



At point L, the electron will be moving straight 'up the page' at this instant, which will be equivalent to a single positive charge moving straight 'down the page' at this instant. Now applying the right hand rule for this positive charge reveals that it will experience a force to the right (that is, 'away from O'). The force will have the same direction if acting on the electron which is moving 'up the page'.

(Alternative C)

References:

Haber-Schaim, 3rd ed., pp. 502–505.
Ingram, Part 1, pp. 180–183.
Mayfield, Book 1, pp. 136–139.
Williams, p. 490.

- 13 **Correct Response: C**

Discussion:

To answer this question, application of Lenz's law is necessary (see item 4). Consider each of the four cases given.

Case I: As the north pole of the magnet moves towards the solenoid as shown, there will be an increase in magnetic flux threading the solenoid from left to right. Hence, a current will be induced in the solenoid producing an opposing flux change which will therefore have a direction from right to left through the solenoid. In other words, the induced secondary flux lines will be from right to left, so Case I is an incorrect solution.

Case II: As the north pole moves away from the solenoid, there will be a decrease in flux threading the solenoid from left to right. Hence, a current will be induced so that an increase in flux from left to right takes place and this will be the direction of the secondary flux lines. So Case II is a correct situation.

Cases III and IV: These are simply the converse situations of Cases I and II respectively, which will mean that Case III is a correct situation and Case IV is an incorrect situation.

References:

Haber-Schaim, 3rd ed., pp. 525–532.
Ingram, Part 1, pp. 189–193.
Mayfield, Book 1, p. 185.
Williams, pp. 464, 475.

- 14 **Correct Response: B**

Discussion:

Once again it is necessary to use Lenz's law (see item 4) to answer the question.

In Case I, as the loop moves into the magnetic field there is an increase in the number of field lines threading the loop. This means an increase in flux threading the loop. To oppose this increase in flux a current will be induced in the loop in an anti-clockwise direction to produce a decrease in flux into the page (right hand screw rule).

In Case II, as the loop moves into a region of weaker field there will be less flux 'into the page', threading the loop and so a current will be induced in a clockwise direction to cause an increase in flux threading the loop into the page (right hand screw rule). Hence alternative B is correct.

References:

Haber-Schaim, 3rd ed., pp. 531–532.
Ingram, Part 1, pp. 186–189.
Mayfield, Book 1, pp. 182–185.
Williams, p. 490.

15-18 Correct Responses: 15 A

16 B

17 C

18 A

Discussion:

- 15 When a switch S is closed a current will flow in coil 1 and a magnetic field will be set up along the iron rod in a direction given by the 'right hand screw' rule for conventional current. Applying this rule, it can be seen that the magnetic field at X will be 'to the right'.

- 16 When S is switched on, current increases from zero to some final value I in coil 1. This current build up in coil 1 is associated with a flux increase through coil 1 (see item 15) and some of this flux links coil 2, causing an induced EMF, and induced current in coil 2. Now if the current in coil 2 were in the direction Q to P , the flux produced by coil 2 would further increase the flux produced by coil 1, and so on. This would lead to an immense energy build up unrelated to the energy source (the battery). So using Lenz's law, the current in coil 2 must be in direction P to Q and by using the right hand screw rule for this current it can be seen that the induced magnetic field at Y due to coil 2 is 'to the left'.

(Alternative B)

- 17 If the magnetic field strength increases at a constant rate, the EMF (and hence the current) induced will be constant since,

$$\varepsilon = \frac{\Delta\phi_B}{\Delta t}$$

If $\frac{\Delta\phi_B}{\Delta t}$ is constant then ε is constant also.

Further, from the argument given in item 16, it can be seen that the current in coil 2 due to coil 1 will be from P to Q . Hence, in coil 2 there will be a constant, non-zero current flowing from P to Q .

(Alternative C)

- 18 The effect of placing the soft iron rod in the solenoid is to greatly increase the magnetic field strength for a given current in the solenoid. The iron atoms in the rod act as tiny magnets and in the presence of the field produced by the solenoid will align themselves with the field thus producing a bar magnet for as long as the current flows. Sliding coil 2 to the right until it is half off the rod has the effect of reducing the amount of iron core in the solenoid and hence reduces the strength of the induced flux in coil 2. This finally leads to a smaller current being induced in coil 2.

(Alternative A)

References:

Haber-Schaim, 3rd ed., pp. 522-532.
Ingram, Part 1, pp. 197-199.
Mayfield, Book 1, p. 185.
Project Physics, Unit 4, pp. 77-81.
Williams, pp. 488-492.

19 and 20 Correct Responses: 19 D

20 D

Discussion:

- 19 In this example, a flux change will result from a change in the effective area of loop exposed to field lines, while magnetic field strength B remains constant, that is

$$\Delta\phi_B = B \cdot (\Delta A)$$

Initially, the plane of the loop is perpendicular to the field and so the area exposed to field lines will be $3 \text{ cm}^2 = 3 \times 10^{-4} \text{ m}^2$

After the loop is rotated through an angle of 90° about axis XX' the plane of the loop will be parallel to the magnetic field. In this position the effective area of loop which can be threaded by field lines will be zero.

So:

$$\begin{aligned}\Delta\phi_B &= B \cdot (\Delta A) \\ &= B \cdot (0 - 3 \times 10^{-4}) \text{ weber} \\ &= 4 \times 10^{-2} \times (-3 \times 10^{-4}) \text{ weber} \\ &= -1.2 \times 10^{-5} \text{ weber}\end{aligned}$$

The minus sign merely gives information about the direction of the resulting EMF.

Hence, the net change of flux through the coil during one quarter of a rotation will be,

$$1.2 \times 10^{-5} \text{ W}$$

- 20 At time $t = 0$, when the plane of the loop is perpendicular to the field, the flux threading the loop is a maximum (because the area exposed to field lines is greatest). At time $t = 1.0 \text{ s}$, when the plane of the loop is parallel to the field, the flux threading the loop will be zero because the effective area of the loop which can be threaded by the field lines is zero. This means that a graph of magnetic flux versus time will be maximum when $t = 0$ and zero when $t = 1.0 \text{ s}$.

(Alternative D)

References:

Haber-Schaim, 3rd ed., pp. 525-532.
Ingram, Part 1, pp. 195, 196.
Mayfield, Book 1, p. 186.
Williams, pp. 488-490.

21-24 Correct Responses: 21 A

22 D

23 B

24 C

Discussion:

- 21 The magnitude of the force F acting on a particle of charge q moving at speed v at right angles to a uniform field of magnetic induction $\vec{B}$ is given by the relation,

$$F = Bqv,$$

where B is the magnitude of the magnetic field $\vec{B}$.

- 22 As the force is always at right angles to the motion, the α -particle will trace out a circular path and the magnetic force will contribute the centripetal force necessary to maintain the circular path, that is,

$$F_{\text{magnetic}} = F_{\text{centripetal}}$$

$$\Rightarrow Bqv = \frac{mv^2}{R}$$

$$\Rightarrow R = \frac{mv}{qB}$$

where R is the radius of the circular path.

- 23 In this example values are:

$$m = 6.7 \times 10^{-27} \text{ kg.}$$

$$v = 4.0 \times 10^4 \text{ m s}^{-1},$$

$$q = 3.2 \times 10^{-19} \text{ C}$$

$$\text{and } B = 4.0 \times 10^{-2} \text{ tesla.}$$

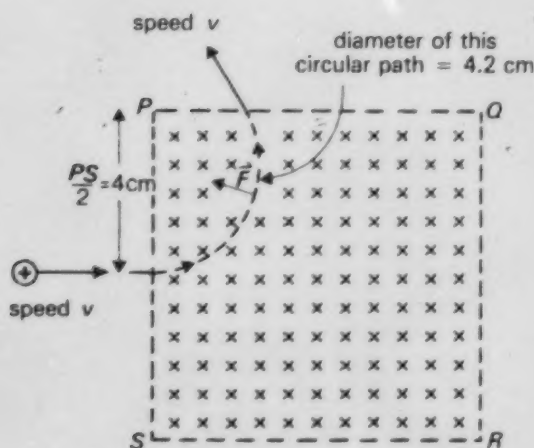
Substituting these values into our expression for R gives:

$$R = \frac{(6.7 \times 10^{-27})(4.0 \times 10^4)}{(3.2 \times 10^{-19})(4.0 \times 10^{-2})} \text{ m}$$

$$\Rightarrow R = 2.1 \times 10^{-2} \text{ m}$$

- 24 The radius of the path is 2.1 cm (see item 23) and the α -particle will trace out a circular path of diameter 4.2 cm. On entering the field at a point midway between P and S it will initially undergo a deflecting force towards the top of the page. However, the diameter of the resulting circular path (4.2 cm) will be slightly larger than $\frac{PS}{2}$ and so the

particle will pass out of the region of magnetic field somewhere between P and Q as shown in the following diagram.



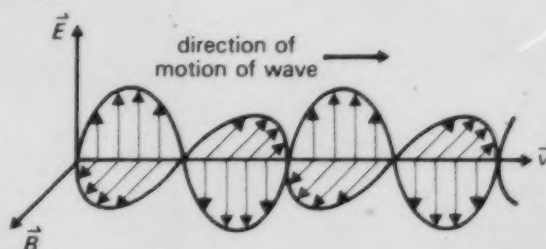
References:

- Haber-Schaim, 3rd ed., pp. 502-505.
Ingram, Part 1, pp. 180-183.
Mayfield, Book 1, pp. 136-139.
Project Physics, Unit 4, pp. 66-68.
Williams, p. 490.

- 25 and 26 Correct Responses: 25 C
26 H

Discussion:

25



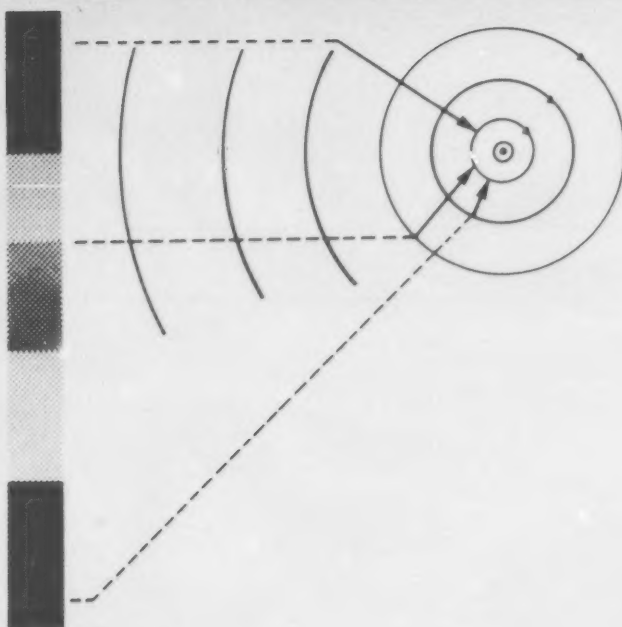
The electric and magnetic field vectors $\vec{E}$ and $\vec{B}$, each vary periodically in the form of a sine wave, each vibrates at right angles to the other with the spacial orientation shown in the diagram and they are both in phase with each other. In this example, the direction of propagation ($\vec{v}$) is 'into the page' and the $\vec{B}$ field is directed 'up the page'. This means that the $\vec{E}$ field will be 'to the left'.

- 26 Because both the magnetic field ($\vec{B}$) and the electric field ($\vec{E}$) have the same direction of propagation and are in phase with each other then the electric field ($\vec{E}$) must also be moving 'into the page'.

References:

- Haber-Schaim, 3rd ed., pp. 540-545.
Mayfield, Book 1, pp. 188-190; Book 2, p. 115.
Project Physics, Unit 4, pp. 107-110.
Williams, p. 285.

ACER Physics Unit Tests



Diagnostic Aid 20 Atomic physics

Description

This diagnostic aid is one of a collection of 21 diagnostic aids corresponding to the 21 separate tests in the *Physics Unit Tests*.

In each diagnostic aid an explanation is provided so that the reasons why the responses are correct or incorrect are available to you.

To gain maximum benefit from the *Physics Unit Tests* weaknesses diagnosed need to be followed up. These diagnostic aids make it possible for you to proceed with this follow up in your own time. If you do not understand the discussion you are advised to seek help from your teacher.

References

The references throughout the Diagnostic Aids have been abbreviated. The abbreviations and full publication details are listed.

- Haber-Schaim: Haber-Schaim, U., Cross, J.B., Dodge, J.H., and Walter, J.A. *PSSC Physics*. 4th ed. Lexington, Mass.: D.C. Heath, 1976. (Reference is also made to 3rd ed.)
- Ingram: Ingram, A.D., Kuhl, D.H., McCarthy, J.E., Sandercock, E.R., Smith, W.F., and Waite, P.J. *Physics: A Laboratory-oriented Approach*. (Study Guide Leaving Part 1, Study Guide Matriculation Part 2). Adelaide: Rigby, 1971, 1972.
- Mayfield: Mayfield, J.M. Parham, R.T., and Webber, B.J. *Fundamentals of Senior Physics*. (Book 1, Book 2). Melbourne: Heinemann Educational Australia Pty Ltd, 1973.
- Project Physics: *Project Physics Course: Programmed Instruction Books* (Kinetic Molecular Theory of Gases, Waves 1-2, Equations 1-3, Vectors 1-3); *Text and Handbook* (Units 1-6). Sydney: Martin Educational, 1970.
- Williams: Williams, J.E., Trinklei, F.E., Metcalfe, H.C., and Lefler, R.W. *Modern Physics*. New York: Holt, Rinehart, & Winston, 1976.

The Australian Council for Educational Research Limited thanks the following publishers for donating textbooks used in referencing the aids: Heinemann Educational Australia Pty Ltd, Richmond, Victoria, for *Fundamentals of Senior Physics*. Rigby Limited, Box Hill, Victoria, for *Physics: A Laboratory-oriented Approach*.

Do not write on this booklet

1 Correct Response: A

Discussion:

Alpha particles carry two positive charges compared to the single negative charge of the beta particle. The alpha particle also has approximately 7300 times the mass of the beta particle. The particles are stopped by their interaction with the lead molecules. Thus the more massive and higher charged alpha particles cause more ionization than the beta particles, that is, the alpha particles have less penetrating ability. Gamma rays do not consist of charged particles; they are electromagnetic waves and have only a weak interaction with the electrons around the lead molecules. Hence, they have the greatest penetrating ability.

References:

Ingram, Part 2, pp. 142, 143.
Mayfield, Book 2, pp. 194-201.
Project Physics, Unit 6, pp. 12, 13.
Williams, p. 605.

2 Correct Response: B

Discussion:

Energy is required to move an electron from the inner orbit to an outer orbit. Hence, when the reverse occurs, energy is released as electromagnetic radiation, that is, light.

References:

Ingram, Part 2, p. 149.
Mayfield, Book 2, pp. 154-156.
Project Physics, Unit 5, pp. 71, 72.
Williams, p. 644.

3 Correct Response: D

Discussion:

An element is determined by the number of protons in the nucleus, called the atomic number. The mass number is the sum of the numbers of protons and neutrons in the nucleus. Isotopes are the same element but with different numbers of neutrons in the nucleus.

References:

Haber-Schaim, 3rd ed., pp. 507, 508.
Ingram, Part 2, p. 190.
Mayfield, Book 2, pp. 176, 177.
Project Physics, Unit 6, p. 32.
Williams, pp. 597, 598.

4 Correct Response: D

Discussion:

A period of 18 years results in a decrease to one-third of the original intensity, I_0 . A further period of 18 years would result in a decrease to one-third of the original one-third. One third of one third is one ninth, so the approximate intensity after 18 more years is $\frac{1}{9} I_0$.

References:

Ingram, Part 2, p. 189.
Mayfield, Book 2, p. 203.
Project Physics, Unit 6, pp. 21, 23.
Williams, p. 6-7-609.

5 Correct Response: A

Discussion:

Uranium -238 decays through a long series to a stable isotope of lead. Half of the uranium has decayed to lead in the first half-life. Half of the remaining uranium decays in the next half life. That is one quarter of the original mass remains and three quarters has decayed to lead. After the next half life only one eighth of the original uranium remains. Hence, the portion of lead present increases rapidly at first and after a few half lives, the increase slows down. Alternative A is the only graph showing these characteristics.

References:

Ingram, Part 2, p. 189.
Mayfield, Book 2, p. 203.
Project Physics, Unit 6, pp. 19, 27.
Williams, p. 607.

6 Correct Response: C

Discussion:

The readings are recorded continuously so that they must always increase. The sixth reading, 9802, is larger than the seventh, 9636, and hence is in error.

References:

Ingram, Part 2, p. 189.
Mayfield, Book 2, p. 203.
Project Physics, Unit 6, p. 21.
Williams, pp. 607-609.

7 Correct Response: B

Discussion:

Since the count rate after the seventh minute is so small compared to the first minute, the number of atoms in the sample is approximately, 10 000. Thus when approximately 5000 atoms have decayed the first half-life has passed. This occurs between $\frac{1}{2}$ and 1 minute since the count at one minute is 6015.

References:

Ingram, Part 2, p. 189.
Mayfield, Book 2, p. 203.
Project Physics, Unit 6, p. 21.
Williams, pp. 607-609.

8 Correct Response: D

Discussion:

The concept of half-life holds when large numbers of atoms are considered. When a single atom or a small number of atoms are considered the half-life is no longer statistically correct. Thus for a single atom, the chance of decay in the first half-life is $\frac{1}{2}$. If the atom has not decayed then, the chance of decaying in the second half-life is still $\frac{1}{2}$. The atom does not age as in the biological sense. Thus for a small number of atoms, say 100, it cannot be expected that exactly 50 will have decayed in the first half-life. Perhaps more or perhaps less have disintegrated. But for a large number of atoms we can statistically expect that approximately half have decayed in the first half-life. Thus the rate of change for the 8th minute is larger than expected, hence random fluctuations have occurred.

References:

Ingram, Part 2, p. 189.
Mayfield, Book 2, p. 203.
Project Physics, Unit 6, p. 21.
Williams, pp. 607–609.

9 Correct Response: B

Discussion:

Here, the right hand rule relating magnetic field, current and force is used. Now, with magnetic field into the page, and force directed downwards and perpendicular to the field, the conventional current must be along the track from *S* to the source. Thus a negatively charged particle coming from the source would follow the track and give the conventional current as required.

References:

Haber-Schaim, 3rd ed., p. 502.
Ingram, Part 2, p. 140.
Mayfield, Book 2, p. 178.
Project Physics, Unit 4, p. 67.

10 Correct Response: C

Discussion:

A less massive particle loses energy more slowly, thus resulting in a longer track. The particle, *T*, has a greater curvature and so it must also move slower.

References:

Ingram, Part 2, pp. 143–145.
Mayfield, Book 2, pp. 197–201.

11 Correct Response: A

Discussion:

Alpha particles produce the largest amount of ionization. The tracks are made due to the condensation of rows of droplets onto charged ions. Beta particles and gamma rays produce less ionization and neutrons do not cause any ionization.

References:

Ingram, Part 2, p. 142.
Mayfield, Book 2, pp. 197, 198.
Project Physics, Unit 6, p. 15.
Williams, p. 625.

12 Correct Response: D

Discussion:

Gamma rays produce less ionization than any of the three other particles mentioned here. Hence, it is most probable that a γ -ray travelled between *X* and *Y* and did not leave a track.

References:

Ingram, Part 2, p. 143.
Mayfield, Book 2, p. 201.
Project Physics, Unit 6, p. 15.

13 Correct Response: A

Discussion:

The particle omitted can be determined from consideration of the atomic and mass numbers shown in the equation. Now the difference in the sum of the atomic numbers is $(12 + 1) - (11) = 2$. The difference in the sum of the mass numbers is $(30 + 1) - (27) = 4$.

Thus, 2 protons and 2 neutrons must be accounted for, which is the composition of an alpha particle.

References:

Mayfield, Book 2, p. 197–201.
Project Physics, Unit 6, p. 68.
Williams, pp. 605–607.

14 Correct Response: B

Discussion:

The mass number is the sum of the numbers of neutrons and protons in the nucleus, that is, the number of nucleons present.

References:

Haber-Schaim, 3rd ed., p. 507.
Ingram, Part 2, p. 181.
Mayfield, Book 2, pp. 176, 177.
Project Physics, Unit 6, p. 58.
Williams, pp. 583, 597.

15 Correct Response: B

Discussion:

Two types of radiation are present—*P* and *Q*. The effect of the magnetic field indicates that only part of the radiation is charged. So either α -particles or β -particles are present, but not both. The medium distance of penetration of the radiation, *P*, indicates most probably β -rays, not the less penetrating α -particles.

The large distance of penetration of the radiation, *Q*, and the knowledge that part of the radiation is unchanged suggests the presence of γ -rays. Hence, alternative **B** is the correct response.

References:

Ingram, Part 2, pp. 142, 143.
 Mayfield, Book 2, pp. 197–201.
 Project Physics, Unit 6, p. 13.
 Williams, p. 605.

16 Correct Response: A**Discussion:**

A nuclei is composed of a small central dense positive core which is surrounded by a cloud of electrons. Thus, the atom is mainly empty space. Alpha particles are positively charged and so are repelled by the positive nucleus. The greater the atomic number, the greater the number of protons or positive charges in the nucleus, thus the greater the deflection. The alpha particles do not readily interact with the electron cloud (Alternative A).

References:

Haber-Schaim, 3rd ed., pp. 560–565.
 Ingram, Part 2, p. 143.
 Mayfield, Book 2, pp. 151–153.
 Project Physics, Unit 5, p. 66.
 Williams, pp. 593–595.

17 Correct Response: A**Discussion:**

Rutherford's model of the atom suggested that atoms consist of a dense, positively charged nucleus surrounded by a cloud of electrons. The α -particles are deflected by the nucleus. Most α -particles passed a considerable distance from the positive core, compared to the size of the nucleus, through the electron cloud and were not deflected. Only those that approached close to the nucleus were deflected. Hence, the experimental results of these scattering experiments suggested alternative A.

References:

Haber-Schaim, 3rd ed., pp. 565–567.
 Ingram, Part 2, p. 143.
 Mayfield, Book 2, pp. 151–153.
 Project Physics, Unit 5, pp. 66–69.
 Williams, p. 594.

18 Correct Response: C**Discussion:**

The number of protons on the left hand side of the equation is 10. Thus the number of protons in X is $10 - 2 = 8$, (since an α -particle has two protons). The number of protons and neutrons on the left hand side of the equation is 20. Therefore, the number of protons and neutrons in X must be $20 - 4 = 16$. Recall that an α -particle consists of two protons and two neutrons. Thus, the isotope produced in the reaction is ${}^{16}_{8}\text{O}$.

References:

Ingram, Part 2, p. 183.
 Mayfield, Book 2, p. 182.
 Project Physics, Unit 6, p. 68.
 Williams, pp. 605–607.

19 Correct Response: D**Discussion:**

The above equation can be used to describe the reaction. On the left hand side the total of the mass numbers is $11 + 4 = 15$. Hence, on the right hand side, the mass number of Z must be $15 - 1 = 14$. One is the mass number of the proton.

References:

Ingram, Part 2, p. 183.
 Mayfield, Book 2, p. 182.
 Project Physics, Unit 6, p. 68.
 Williams, pp. 605–607.

20 Correct Response: B**Discussion:**

An apparent loss of mass occurred when the particles combined. According to the equation $E = mc^2$, (where E represents energy, m the mass and c the speed of light), mass and energy are interchangeable. The loss in mass has occurred due to a release of energy during the formation of deuterium. Similarly, to break up the deuterium atom, energy equivalent to that lost must be supplied.

References:

Ingram, Part 2, pp. 193, 194.
 Mayfield, Book 2, p. 189.
 Project Physics, Unit 6, pp. 76, 79.
 Williams, p. 599.

21 Correct Response: D**Discussion:**

Transuranic elements are elements of atomic number greater than that of uranium – 92. Such elements do not occur in nature, but may be obtained by nuclear reactions. Alternative D is the only response which shows the formation of a transuranic element.

References:

Ingram, Part 2, p. 196.
 Mayfield, Book 2, p. 206.
 Project Physics, Unit 6, p. 81.
 Williams, p. 612.

22 Correct Response: A

Discussion:

A form of nuclear fission is the splitting of an atom by a neutron into two or more elements, with, at the same time, the emission of neutrons. A is the only alternative in which this occurs.

References:

Ingram, Part 2, pp. 195–200.
Mayfield, Book 2, p. 207.
Project Physics, Unit 6, p. 81.
Williams, pp. 611–613.

23 Correct Response: C

Discussion:

Isotopes of the same element have the same atomic number, but different mass numbers. In this example, alternative C shows two elements with atomic numbers of 66 but with different mass numbers (156 and 160) and hence must be the required answer.

References:

Haber-Schaim, 3rd ed., pp. 507, 508.
Ingram, Part 2, p. 190.
Mayfield, Book 2, p. 185.
Project Physics, Unit 6, p. 31.
Williams, p. 597.

24 Correct Response: D

Discussion:

Half (50 per cent) of the thallium would decay in one half life. Half of the remaining 50 per cent would decay in the next half life. Thus, after two half lives, only one quarter of the thallium remains, that is 75 per cent has decayed in 264 s.

References:

Ingram, Part 2, p. 189.
Mayfield, Book 2, p. 203.
Project Physics, Unit 6, p. 21.
Williams, pp. 607–609.

25 Correct Response: B

Discussion:

The potential energy of the sphere is zero at infinity. As the sphere approaches X , it slows down and loses kinetic energy which is transformed into potential energy in the electric field. Thus the sphere has less kinetic energy at Q than at P but not zero kinetic energy, as it is still moving.

References:

Haber-Schaim, 3rd ed., p. 424.
Project Physics, Unit 3, p. 36.
Williams, p. 142.

26 Correct Response: D

Discussion:

Kinetic energy is a scalar quantity. Since the interaction is elastic, the total energy is conserved. The sphere is the same distance, d , from X , at both P and R . Hence, at these two positions it has the same potential and therefore kinetic energy—alternative D.

References:

Haber-Schaim, 3rd ed., p. 424.
Project Physics, Unit 3, p. 36.
Williams, p. 142.

27 Correct Response: C

Discussion:

When an electron is detached from the sodium atom, the atom is ionized. From the diagram, the minimum energy required to ionize the sodium atom is 5.13 eV. Bombarding energy less than 5.13 eV may excite the valence electrons but not detach them from the atom.

References:

Haber-Schaim, 3rd ed., pp. 597–601.
Ingram, Part 2, p. 150.
Mayfield, Book 2, p. 157.
Project Physics, Unit 5, p. 75.
Williams, p. 650.

28 Correct Response: C

Discussion:

The energy of the bombarding electrons is 3.30 eV. The maximum energy level attained by the sodium using these electrons is 3.19 eV. The energy difference, 0.11 eV, will be retained as kinetic energy by the bombarding electron. Thus the excited sodium atom may emit photons by decaying from the 3.19 eV level to the ground state or 3.19 eV to 2.10 eV, emitting a photon of $3.19 - 2.10 = 1.09$ eV, then to the ground state emitting a photon of 2.10 eV. No other transitions can occur.

References:

Haber-Schaim, 3rd ed., pp. 597-601.
Ingram, Part 2, p. 150.
Mayfield, Book 2, pp. 143, 144.
Project Physics, Unit 5, p. 75.

29 Correct Response: A

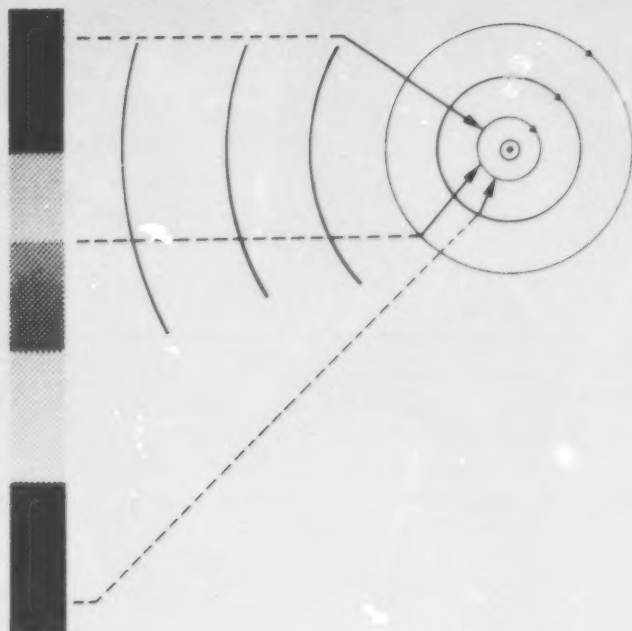
Discussion:

A 3.50 eV electron produces a 1.09 eV photon after exciting a sodium atom to one of the energy levels from the ground state. The only energy level to produce a 1.09 eV photon would be a decay from 3.19 eV to 2.10 eV. Thus the 3.50 eV bombarding electron has lost 3.19 eV resulting in the electron retaining 0.31 eV ($3.50 - 3.19 = 0.31$ eV). The sodium atom has yet to drop from the 2.10 eV energy level to the ground state.

References:

Haber-Schaim, 3rd ed., pp. 597-599.
Ingram, Part 2, pp. 155, 156.
Mayfield, Book 2, p. 157.
Project Physics, Unit 5, p. 79.

ACER Physics Unit Tests



Diagnostic Aid 21 Quantum physics

Description

This diagnostic aid is one of a collection of 21 diagnostic aids corresponding to the 21 separate tests in the *Physics Unit Tests*.

In each diagnostic aid an explanation is provided so that the reasons why the responses are correct or incorrect are available to you.

To gain maximum benefit from the *Physics Unit Tests* weaknesses diagnosed need to be followed up. These diagnostic aids make it possible for you to proceed with this follow up in your own time. If you do not understand the discussion you are advised to seek help from your teacher.

References

The references throughout the Diagnostic Aids have been abbreviated. The abbreviations and full publication details are listed.

- Haber-Schaim: Haber-Schaim, U., Cross, J.B., Dodge, J.H., and Walter, J.A. *PSSC Physics*. 4th ed. Lexington, Mass.: D.C. Heath, 1976. (Reference is also made to 3rd ed.)
- Ingram: Ingrah, A.D., Kuhl, D.H., McCarthy, I.E., Sandercock, E.R., Smith, W.F., and Waite, P.J. *Physics: A Laboratory-oriented Approach*. (Study Guide Leaving Part 1, Study Guide Matriculation Part 2). Adelaide: Rigby, 1971, 1972.
- Mayfield: Mayfield, J.M. Parham, R.T., and Webber, B.J. *Fundamentals of Senior Physics*. (Book 1, Book 2). Melbourne: Heinemann Educational Australia Pty Ltd, 1973.
- Project Physics: *Project Physics Course: Programmed Instruction Books* (Kinetic Molecular Theory of Gases, Waves 1-2, Equations 1-3, Vectors 1-3); *Text and Handbook* (Units 1-6). Sydney: Martin Educational, 1970.
- Williams: Williams, J.E., Trinklei, F.E., Metcalfe, H.C., and Lefler, R.W. *Modern Physics*. New York: Holt, Rinehart, & Winston, 1976.

The Australian Council for Educational Research Limited thanks the following publishers for donating textbooks used in referencing the aids: Heinemann Educational Australia Pty Ltd, Richmond, Victoria, for *Fundamentals of Senior Physics*. Rigby Limited, Box Hill, Victoria, for *Physics: A Laboratory-oriented Approach*.

Do not write on this booklet

1 Correct Response: A

Discussion:

Increasing the intensity of light, increases the amplitude of the electromagnetic wave. Thus, the wave model predicts that an increase in intensity will result in an increase in the excess energy of photoelectrons.

Alternatives B and C refer to the photon or particle model of light.

References:

Haber-Schaim, 3rd ed., pp. 572-575.
Ingram, Part 2, p. 111.
Mayfield, Book 2, p. 119.
Project Physics, Unit 5, p. 42.
Williams, p. 288.

2 Correct Response: B

Discussion:

The energy of a photon is given by the equation $E = h\nu$, where h is Planck's constant and ν is the frequency of the light. Thus, an increase in the frequency results in an increase in the energy of the photons, and this is then transferred to the photoelectrons.

An increase in intensity would result in an increase in the number of photoelectrons, not their energy.

References:

Haber-Schaim, 3rd ed., pp. 577-581.
Ingram, Part 2, pp. 114-116.
Mayfield, Book 2, pp. 122-124.
Project Physics, Unit 5, p. 44.
Williams, p. 292.

3 Correct Response: D

Discussion:

Energy of photons is proportional to frequency. Hence the light with the largest frequency (or shortest wavelength) has the greatest energy per photon.

In this item, violet light has the greatest frequency of the light mentioned and therefore the faint violet light is the correct choice. Note that the intensity of the light does not affect its energy per photon.

References:

Haber-Schaim, 3rd ed., pp. 577-581.
Ingram, Part 2, pp. 114-118.
Mayfield, Book 2, pp. 122-124.
Project Physics, Unit 5, p. 44.
Williams, p. 292.

4 Correct Response: D

Discussion:

Before a metal cathode will emit electrons, the electrons require a minimum energy to escape. The frequency of light is proportional to the energy of individual photons. Since electrons are emitted, causing the residual current, the energy of the photons must be above the threshold energy.

References:

Haber-Schaim, 3rd ed., pp. 577-581.
Ingram, Part 2, pp. 114-116.
Mayfield, Book 2, p. 122.
Project Physics, Unit 5, pp. 41, 42.
Williams, pp. 292, 293.

5 Correct Response: B

Discussion:

Since the current has reached saturation, that is, the current does not increase with increasing voltage, the maximum number of photoelectrons emitted per second are arriving at the anode.

References:

Haber-Schaim, 3rd ed., pp. 577-581.
Ingram, Part 2, pp. 114-116.
Mayfield, Book 2, p. 122.
Williams, p. 293.

6 Correct Response: C

Discussion:

Since neither the frequency of light nor its intensity have been altered, alternatives A and B are incorrect. To create a current, electrons have to cross the cell and arrive on the opposite side. Since the polarity has been reversed and it is observed that a decrease in current has occurred, this suggests that fewer photoelectrons now have sufficient kinetic energy to cross the opposing electric field.

References:

Haber-Schaim, 3rd ed., pp. 577-581.
Ingram, Part 2, pp. 114-116.
Mayfield, Book 2, p. 122.
Project Physics, Unit 5, p. 44.
Williams, p. 293.

7 Correct Response: C

Discussion:

Intensity is not related to the energy per photon. This energy is proportional to frequency. Therefore, by changing the intensity, the cut-off potential is unaffected.

References:

Haber-Schaim, 3rd ed., pp. 577-581.
 Ingram, Part 2, pp. 114-116.
 Mayfield, Book 2, p. 122.
 Project Physics, Unit 5, p. 42.
 Williams, p. 293.

8 Correct Response: B**Discussion:**

Frequency is proportional to energy per photon. An increase in frequency results in photons of higher energy, hence a larger negative potential is required to stop the flow of current.

References:

Haber-Schaim, 3rd ed., pp. 577-581.
 Ingram, Part 2, pp. 114-116.
 Mayfield, Book 2, p. 122.
 Project Physics, Unit 5, p. 42.
 Williams, p. 293.

9 Correct Response: C**Discussion:**

The work function is the minimum energy required for electrons to be released from the metal.

Now,

$$3.7 \text{ eV} = 3.7 \times 1.6 \times 10^{-19} \text{ J} = 5.92 \times 10^{-19} \text{ J}.$$

Since $E = h\nu$

$$5.92 \times 10^{-19} = 6.6 \times 10^{-34} \nu$$

$$\text{giving } \nu = 9.0 \times 10^{14} \text{ Hz}$$

References:

Haber-Schaim, 3rd ed., pp. 577-581.
 Ingram, Part 2, pp. 114-116.
 Mayfield, Book 2, p. 122.
 Project Physics, Unit 5, p. 44.
 Williams, p. 293.

10 Correct Response: D**Discussion:**

The formula for the de Broglie wavelength is:

$$\begin{aligned} \lambda &= \frac{h}{mv} \\ &= \frac{6.6 \times 10^{-34}}{1.0 \times 10^{-30} \times 5.0 \times 10^7} \\ &= 1.3 \times 10^{-11} \text{ m} \end{aligned}$$

References:

Haber-Schaim, 3rd ed., pp. 610-613.
 Ingram, Part 2, p. 124.
 Mayfield, Book 2, p. 130.
 Williams, p. 649.

11 Correct Response: C**Discussion:**

The work function is the minimum energy which must be supplied to free electrons from a surface (see item 9). Here the equation to the straight line is,

$$K = mv - K_2$$

The value of the work function occurs when $K = 0$ and so the energy which must be supplied is $mv = K_2$.

Hence, the most direct measure is K_2 .

References:

Haber-Schaim, 3rd ed., pp. 577-581.
 Ingram, Part 2, pp. 114-116.
 Mayfield, Book 2, p. 122.
 Project Physics, Unit 5, p. 44.
 Williams, p. 293.

12 Correct Response: B**Discussion:**

The work function is K_2 . The maximum energy of the ejected electron is K_1 . Hence, the energy of the incident photon, E , must be $K_1 + K_2$.

References:

Haber-Schaim, 3rd ed., pp. 577-581.
 Ingram, Part 2, pp. 114-116.
 Mayfield, Book 2, p. 122.
 Project Physics, Unit 5, p. 44.
 Williams, p. 293.

13 Correct Response: B**Discussion:**

In the Compton effect, part of the x-rays' momentum is transferred to the ejected electron and part is redirected as a photon of reduced momentum. The Compton effect can be observed in a cloud chamber and momentum is conserved. The fact that momentum is given to the electron implies that x-ray photons have momentum.

References:

Haber-Schaim, 3rd ed., pp. 581-583.
 Ingram, Part 2, pp. 122, 123.
 Mayfield, Book 2, p. 129.

14 Correct Response: C**Discussion:**

It can be shown mathematically that the relation between the wavelength of the scattered x-rays, λ' , and the angle θ that the scattered ray makes with the incident beam, is given by,

$$\lambda' = \lambda + \frac{h}{m_0 c} (1 - \cos \theta),$$

where λ is the wavelength of the incoming x-ray, h is Planck's constant, m_0 is the mass of scattered electron and c is the velocity of light.

A plot of this curve between λ' and θ gives the curve shown in alternative C, hence curve C gives the required relationship.

References:

Haber-Schaim, 3rd ed., pp. 581–583.
Ingram, Part 2, pp. 122, 123.
Mayfield, Book 2, p. 129.

15 Correct Response: D**Discussion:**

The ground state refers to the zero level on the diagram. The transitions required all terminate at the ground state—alternative D.

References:

Haber-Schaim, 3rd ed., pp. 594–596.
Ingram, Part 2, pp. 150, 151.
Mayfield, Book 2, pp. 156–159.
Project Physics, Unit 5, pp. 75–82.
Williams, pp. 294–296.

16 Correct Response: D**Discussion:**

The energy of a photon will be equal to the energy of the transition of the electron from a higher to a lower energy state. The energy of a photon is proportional to the frequency. Hence, the largest transition, VIII, will produce the highest frequency.

References:

Haber-Schaim, 3rd ed., pp. 597–601.
Ingram, Part 2, pp. 150, 151.
Mayfield, Book 2, pp. 156–159.
Project Physics, Unit 5, pp. 75–82.
Williams, pp. 294–296.

17 Correct Response: C**Discussion:**

$$E = h\nu$$

$$\text{so, } E = 4 \cdot 14 \times 10^{-15} \text{ eV} \cdot \text{s} \times 5 \times 10^{14} \text{ s}^{-1} \\ \approx 2 \text{ eV}$$

A transition of about 2 eV is required. From the diagram, it can be seen that IV results in a transition of 1.9 eV.

(Alternative C)

References:

Haber-Schaim, 3rd ed., pp. 597–601.
Ingram, Part 2, pp. 150, 151.
Mayfield, Book 2, pp. 156–159.
Project Physics, Unit 5, p. 82.
Williams, pp. 294–296.

18 Correct Response: B**Discussion:**

The de Broglie wavelength is given by $\lambda = \frac{h}{p}$, where h is Planck's constant and p is the momentum.

The energy of the photon is $E = h\nu = \frac{hc}{\lambda} = pc$

where ν is the frequency and c is the velocity of light. The energy of the electron is $E = \frac{1}{2}mv^2$ (if v , the velocity of the electron, $< c$), therefore

$$E = \frac{pv^2}{2}$$

Thus, if the momenta are equal, then the wavelengths are equal, from $\lambda = \frac{h}{p}$, but the energies are not the same since c and v are very different.

References:

Haber-Schaim, 3rd ed., pp. 581–583.
Ingram, Part 2, pp. 124, 125.
Mayfield, Book 2, p. 130.
Williams, p. 296.

19 Correct Response: A**Discussion:**

The energy of the incident photons is $h\nu$.

$h\nu = E + E_w$, where E_w is the work function of the electrons.

Thus,

$$E_w = h\nu - E \dots (1)$$

The threshold frequency occurs when E is zero,

$$\text{therefore } E_w = h\nu_w \dots (2)$$

Hence, from (1) and (2), $v_w = v - \frac{E}{h}$, where v_w is the threshold frequency for the surface.

References:

Haber-Schaim, 3rd ed., pp. 577-581.
Project Physics, Unit 5, p. 44.
Williams, p. 293.

20 Correct Response: D

Discussion:

The energy of the incident photons are

$$E = h\nu = E_k + E_w,$$

where E_w is the work function of the electrons and E_k is the kinetic energy of the ejected electrons.

So $E_k = h\nu - E_w$.

For different surfaces, E_w is different, so the graphs of V versus ν are straight lines of the same gradient h and a y -intercept of $-E_w$.

(Alternative D)

References:

Haber-Schaim, 3rd ed., pp. 577-581.
Ingram, Part 2, pp. 114-116.
Mayfield, Book 2, pp. 122-124.
Project Physics, Unit 5, p. 42.
Williams, p. 293.

21 Correct Response: D

Discussion:

For a photon to be absorbed it must possess exactly the energy of one of the energy levels, otherwise it will not interact with the electron.

The value 3.0 eV is in between two energy levels and hence the photon continues to move with the same 3.0 eV of energy.

References:

Haber-Schaim, 3rd ed., pp. 601-604.
Ingram, Part 2, p. 233.
Mayfield, Book 2, p. 144.

22 Correct Response: B

Discussion:

X-rays are produced by two different interactions of the bombarding electrons and the anode. The electron may be deflected by the positively charged nucleus and thus a change in velocity occurs. Any change in velocity will produce an acceleration and hence the accelerated charge will produce photons or x-rays. This is the continuous x-ray emission of the tube. The peaks are produced by the collision of the electrons with the inner electrons of the target atom in which one of the inner electrons may be dislodged. This leaves a vacant space which is immediately filled by an electron from an outer

shell. The readjustment of the electrons is accompanied by a decrease in the energy of the atom, and an x-ray photon is emitted with energy equal to this decrease.

An increase in the filament current will therefore increase the number of electrons and so increase the intensity of x-rays (Alternative B). However, an increase in operating potential will increase the energy of the electrons and hence the intensity of x-rays as well. Alternative A would also be correct if the word 'only' was not present.

'only' was not present.

References:

Ingram, Part 2, p. 121.
Mayfield, Book 2, p. 126.
Project Physics, Unit 5, p. 52.

23 Correct Response: C

Discussion:

The peaks are produced by a collision of the electrons with the target atoms in which an inner electron is dislodged (see item 22). This leaves a vacant space which is immediately filled by an outer electron with the emission of an x-ray.

Thus, another metal anode must be introduced to change the frequencies of the peaks.

References:

Haber-Schaim, 3rd ed., pp. 597-601.
Ingram, Part 2, p. 121-122.
Mayfield, Book 2, p. 127.

24 Correct Response: D

Discussion:

To produce peaks X, Y and Z the electrons need a high amount of energy to dislodge an inner shell electron of the target atom. An increase in filament current increases the number of electrons produced, thus an increase in intensity of all the peaks will occur. However, an increase in operating potential increases the energy of the electrons and hence, also increases the probability of collisions producing X, Y and Z peaks. (Alternative D)

References:

Haber-Schaim, 3rd ed., pp. 476, 477.
Ingram, Part 2, p. 154.
Mayfield, Book 2, p. 127.

25 Correct Response: A

Discussion:

The equation of the line is,

$$E = h\nu - B,$$

where B is the cut-off potential, h is Planck's constant, ν is the frequency of the incident photons and E is the energy of the emitted electrons. Thus the gradient of the line is h , that is, Planck's constant.

References:

Haber-Schaim, 3rd ed., pp. 577-581.

Ingram, Part 2, pp. 114-116.

Mayfield, Book 2, pp. 122-124.

Project Physics, Unit 5, p. 42.

Williams, p. 293.

26 Correct Response: C

Discussion:

The frequency is 6×10^{14} cycles per second and using this value on the graph gives the intercept with the straight line as 2.4×10^{-19} joules on the energy axis.

References:

Haber-Schaim, 3rd ed., pp. 577-581.

Ingram, Part 2, p. 114.

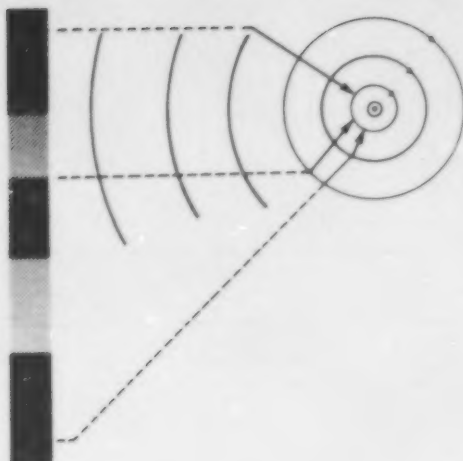
Mayfield, Book 2, p. 123.

Project Physics, Unit 5, pp. 42-44.

Williams, p. 293.

ACER Physics Unit Tests

Teachers Handbook



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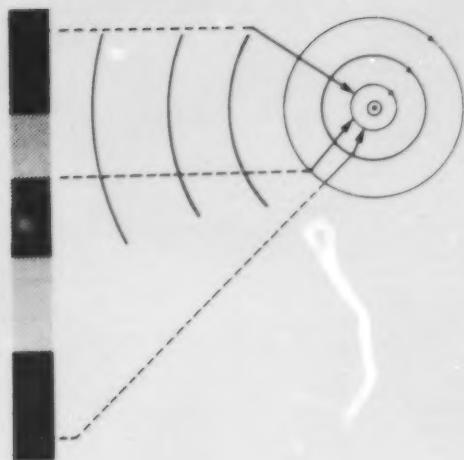
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ACER
Physics
Unit Tests

**Teachers
Handbook**

Graeme Wilmot



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Standardization of Nomenclature for Grades/Years of Schooling

The numbering system recommended by the Australian Education Council in October 1974 has been adopted by the ACER. The Council recommended that '... the years of schooling be called Year 1 to Year 12, with the final year of secondary schooling being called Year 12, and numbering downward through primary school to Year 1...' (Report p. 2).

The *ACER Physics Unit Tests* comprise 21 Unit Tests, 21 Diagnostic Aids and Teachers Handbook.

ACER Physics Unit Tests symbol adapted from 'Spectrum of hydrogen gas', p. 338, *The Ascent of Man*, J. Bronowski, courtesy Rita Bronowski.

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Acknowledgments

The assistance and co-operation of the Victorian Education Department is gratefully acknowledged. This program was initially developed by Mr Kevin Kee who undertook the survey needed to select the appropriate units to be included, and who was responsible for the development of four of the tests. Mr Kee was seconded to the ACER from the Victorian Education Department. Mr Graeme Wilmot, also seconded from the Victorian Education Department, was responsible for the completion of the project when Mr Kee returned to the Department.

Both Mr Kevin Kee and Mr Graeme Wilmot worked under the general supervision of Mr Peter Thomson. Other colleagues at the ACER who assisted at different times were Mr Peter Allanson, Dr Lincoln Bennett, Mr Greg Cornish, Mr Murray Cropley, Mr George Morgan and Mr John Owen, as well as those from service and clerical sections.

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The co-operation of the large number of people who gave much help in trial testing items in the schools in each of the States is gratefully acknowledged.

Diagnostic Aids

The Diagnostic Aids for the Physics Unit Tests were written by the following teachers:

Messrs Jim Allen, Graeme Doig, Kim Fallon, Paul Ferguson, Kevin Kee, Graeme Lofts, Brian McKittrick, Kevin Morrish, Danny O'Keefe, Luciano Puggioni, Brian Rogers, and John Whitechurch.

Development of the tests

The *ACER Physics Unit Tests* were developed when the earlier programs, written for the Victorian and Queensland physics courses, no longer met current requirements in the schools.

The *Physics Unit Tests* are designed to assist in the diagnostic evaluation of students' progress in the study of Physics during the last two years of secondary schooling. There is no undue emphasis on any one course in Physics so that the tests are suitable throughout Australia.

Some of the items used in the earlier programs were retained for the current series but, in addition, many items were obtained from experienced physics teachers in various States who wrote new items specifically for the tests. Discussion sessions, involving ACER staff and teachers of Physics at secondary and tertiary levels, were held so that draft items could be reviewed and revised. At the completion of these sessions, these items were assembled into trial form tests. Two, and sometimes three, trial tests were constructed for each unit, allowing a range of items to select from, for the final single test for each unit. These trial forms enabled an item analysis to be completed before final selection of the items to be published was made.

Final testing was carried out in schools in all Australian States. During the item analysis, consideration was given to content validity, and also to discrimination power and difficulty of each item. In addition, many teachers using trial forms offered critical comments on the tests.

Further review panels were held at the ACER to once again revise and edit items prior to publication.

Description of the material

The *Physics Unit Tests* consist of a collection of 21 separate tests, each related to a different topic and a collection of 21 diagnostic aids covering topics corresponding to the tests. The selection of the topics was made after an Australia-wide survey in which teachers of Years 11 and 12 Physics were asked to specify the content material covered in courses on Physics at their schools. This was to ensure that all major topics taught throughout Australia were covered by the tests.

Format of tests and aids

The tests and diagnostic aids are bound in such a form as to allow individual or collective use.

Topics

The final selection of topics, together with the sub-topics included within each unit, is:

1 Physical measurement

- SI units and prefixes
- Order of magnitude
- Significant figures
- Dimensional analysis
- Vernier scales
- Errors

2 Vectors

- Vectors and scalars
- Addition and subtraction of vectors
- Resolution of vectors
- Relative motion

3 Motion in one dimension

- Speed, velocity and acceleration
- Average speed and velocity
- Average acceleration
- Graphs
- Instantaneous velocity and acceleration
- Constant acceleration formulae
- Free-falling bodies
- Ticker-timers and multiframe

4 Motion on a plane

- Uniform circular motion
- Centripetal force and acceleration
- Projectile motion

5 Dynamics

- Newton's first law – law of inertia
- Newton's second law – inertial mass
- Newton's third law – action and reaction
- Mass and weight
- Resolution of forces and net force

6 Work and energy

Work done by a constant force

Work done by a variable force

Power

Kinetic energy

Gravitational potential energy

Elastic potential energy

Conservation of energy

Elastic and inelastic interactions

7 Linear momentum

Impulse and momentum

Centre of mass

Conservation of momentum – one dimension

Conservation of momentum – two dimensions

8 Oscillations

Simple harmonic motion

Application of simple harmonic motion

Relations between simple harmonic motion and uniform circular motion

9 Gravity and Kepler's law

Law of universal gravitation

Gravitational constant

Kepler's laws

Descriptive astronomy

Artificial satellites

Problems of the solar system

The sun and stars

Galaxies and cosmology

10 Waves

Types of waves – longitudinal and transverse

Superposition principle

Stationary waves

Interference

Diffraction

Refraction and reflection

11 Light – reflection and refraction

Laws of reflection and refraction
Images (mirrors and thin lenses)
Snell's law and refractive index
Critical angle and total internal reflection
Ray tracing
Lens and mirror formulae

12 Light – interference diffraction and spectra

Coherence and phase
Interference from two point sources
Diffraction – single slit
Diffraction – gratings
Resolution
X-ray diffraction
Thin films
Spectrometer
Emission and absorption spectra
Fraunhofer lines

13 Models of light

Relevant properties of water waves
Relevant properties of pulses on a string
Characteristics of the wave model
Characteristics of the particle model
Comparison of the models with observed behaviour of light

14 Kinetic theory of gases

Boyle's and Charles' laws
Ideal gas equation
Kinetic theory of gases
Temperature and molecular kinetic energy

15 Static charges

- The electric charge and its effect
- Conductors and insulators
- Distribution of charges
- Methods of charging
- Detection of charges – the electroscope

16 Electric field and potential difference

- The electric field
- The electric field strength, E
- Lines of force
- Calculation of E
- Electric potential
- Electric potential energy

17 Current electricity

- Ohm's law
- Electricity energy and power
- Measuring resistance
- Series and parallel circuits
- Calculating current, resistance and potential difference
- Potentiometer and Wheatstone bridge

18 The magnetic field

- Magnetic field of magnets and currents
- Magnetic field strength
- Forces on a current in a magnetic field
- Forces on a moving charged particle
- Magnetic field near a long straight wire

19 Induced emf

Faraday's law

Lenz's law

Value of emf

20 Atomic physics

Atomic number, mass number and amu

Isotopes

Half-life

α , β and γ radiation

Geiger counter and cloud chamber

Absorption of particles

Plum pudding model

Rutherford model

Bohr model

Bound states and binding energy

Balancing nuclear reactions

$E = mc^2$

Mass defect

Subatomic particles

Fission

21 Quantum physics

Quanta

Photo-electric effect

Thermionic effect

Photons

X-rays

Matter waves

Compton effect

Most of the topics are clear-cut and the classification of items using these headings present little difficulty. However there is some overlap in some of the units. For instance, the classification of an item as belonging to either Atomic Physics or Quantum Physics is not always easy. Some questions could be classified in either of the two topics and hence their inclusion in one or the other topic is relatively arbitrary.

Number of items

There are between 25 to 30 items in each test. These items are mainly presented in a multiple-choice format where the student is required to select the correct response from between three to five alternatives. The majority of the questions have four alternatives.

Time allowed

There are no time limits for the tests but it is suggested that, in most cases, 40 minutes would be sufficient time for students to complete one test. The tests are not speed tests and teachers will need to use their judgments as to the time needed. Some teachers may choose to use the tests as homework assignments.

Scoring the tests

Answers to the test items have been included in the handbook for convenience. How the answers are presented to the students is left to the teacher's discretion, but it is suggested that one of the following techniques be adopted. At the completion of the test, either

- (1) the answers are read out to the class, or
- (2) the answers are written up on the blackboard, or
- (3) the answers are photostatted and distributed to the students.

Any of these methods could be used to correct the test after it is administered. It should be noted that the correct answers are also included with the diagnostic aids.

Administration and uses of the tests

Probably the best time to administer a test is within two weeks of the completion of the appropriate section of the work. In this way, misconceptions can be identified before they become too firmly fixed in the students' thinking, and important ideas that carry over into other sections of the work can be clarified and reinforced. This method of administration is recommended, although some teachers may prefer to use the tests for revision at a later time in the year.

In whatever way the tests are used, they are intended to be made part of the normal teaching program so that students view them as aids to learning and not as a final testing of achievement in Physics.

It is quite possible that not all of the topics will be applicable to any one school's curriculum. Naturally, the decision as to which tests should be given is at the teacher's discretion. Further, it may be that

some items in a particular test have not been covered in a course. For example, the Wheatstone bridge or potentiometer items may not be dealt with by some schools in the Current Electricity unit. Where possible, items less commonly used in schools have been put at the end of each test. The items to be presented to students are left to the discretion of the teacher.

It is hoped that the wide range of topics and the great number of items will allow use in connection with most courses at schools.

Although the tests are designed as an aid to students in revising and consolidating their work, they are useful to the teacher planning instruction. Examination of class results on individual items will indicate areas of teaching which have or have not been particularly successful.

Finally, it should be stressed that for students to gain maximum benefit from the tests, it is not sufficient just to take a test. The follow-up, in which an attempt is made to do something about any weaknesses diagnosed, is very important to the successful use of the tests. Perhaps it would be ideal if the tests could become the property of the individual student for the duration of the course in Physics for re-use as required.

Test 1
Physical measurement

Test 2
Vectors

1	C	16	B
2	D	17	D
3	B	18	D
4	C	19	D
5	C	20	B
6	A	21	A
7	A	22	C
8	D	23	D
9	B	24	B
10	A	25	A
11	B	26	B
12	A	27	B
13	C	28	C
14	A		
15	D		

1	B	16	C
2	B	17	C
3	A	18	D
4	A	19	C
5	C	20	B
6	B	21	C
7	A	22	B
8	D	23	B
9	B	24	C
10	B	25	B
11	C	26	A
12	C	27	C
13	C	28	D
14	C		
15	D		

Test 3
Motion in one dimension

Test 4
Motion on a plane

1	D	16	B
2	D	17	B
3	A	18	A
4	B	19	B
5	C	20	A
6	B	21	D
7	E	22	C
8	C	23	B
9	D	24	D
10	C	25	C
11	A	26	D
12	A	27	A
13	C		
14	B		
15	C		

1	B	16	B
2	D	17	B
3	C	18	A
4	A	19	A
5	B	20	D
6	A	21	A
7	A	22	C
8	A	23	C
9	E	24	B
10	C	25	D
11	B	26	C
12	D	27	C
13	D	28	D
14	B	29	D
15	C	30	B

Test 5 Dynamics

Test 6 Work & energy

1	C	16	B
2	D	17	C
3	C	18	A
4	B	19	B
5	C	20	D
6	B	21	A
7	A	22	A
8	A	23	C
9	D	24	D
10	A	25	C
11	B	26	C
12	B	27	D
13	D	28	A
14	C	29	B
15	D		

1	C	16	A
2	A	17	C
3	B	18	B
4	D	19	C
5	A	20	B
6	D	21	C
7	D	22	A
8	D	23	C
9	A	24	B
10	A	25	D
11	B	26	D
12	A	27	B
13	B	28	C
14	C	29	B
15	D		

Test 7
Linear momentum

Test 8
Oscillations

1	D	16	B
2	D	17	C
3	C	18	A
4	A	19	B
5	D	20	B
6	B	21	B
7	C	22	C
8	A	23	C
9	D	24	B
10	D	25	C
11	B	26	C
12	A	27	A
13	A	28	D
14	B	29	B
15	D	30	A

1	B	16	B
2	D	17	D
3	C	18	D
4	C	19	A
5	C	20	B
6	A	21	A
7	A	22	B
8	A	23	D
9	C	24	D
10	D	25	F
11	B	26	B
12	A	27	C
13	C	28	E
14	A	29	C
15	B	30	D

Test 9
Gravity & Kepler's laws

Test 10
Waves

1	D	16	D
2	A	17	A
3	C	18	B
4	D	19	B
5	A	20	B
6	B	21	D
7	C	22	C
8	D	23	E
9	B	24	B
10	A	25	C
11	D	26	B
12	C		
13	A		
14	A		
15	C		

1	C	16	B
2	C	17	D
3	B	18	A
4	A	19	B
5	D	20	C
6	A	21	D
7	C	22	D
8	B	23	A
9	D	24	D
10	C	25	B
11	C	26	C
12	A	27	B
13	A	28	B
14	B	29	A
15	A	30	D

Test 11
Light – reflection
and refraction

1	B	16	B
2	B	17	A
3	B	18	D
4	A	19	D
5	C	20	A
6	A	21	C
7	C	22	E
8	D	23	B
9	C	24	D
10	D	25	E
11	A	26	C
12	A		
13	D		
14	B		
15	C		

Test 12
Light – interference,
diffraction & spectra

1	C	16	B
2	A	17	A
3	B	18	B
4	A	19	D
5	C	20	A
6	D	21	B
7	B	22	B
8	D	23	C
9	D	24	A
10	F	25	C
11	D	26	A
12	B	27	D
13	C		
14	C		
15	C		

Test 13
Models of light

Test 14
Kinetic theory of gases

1	A	16	C
2	B	17	A
3	D	18	C
4	C	19	D
5	B	20	D
6	D	21	B
7	A	22	C
8	B	23	C
9	A	24	A
10	D	25	D
11	C		
12	B		
13	A		
14	B		
15	C		

1	C	16	D
2	B	17	C
3	A	18	A
4	B	19	B
5	B	20	A
6	C	21	D
7	D	22	A
8	D	23	A
9	D	24	D
10	A	25	D
11	C	26	A
12	B	27	B
13	C	28	C
14	B	29	C
15	C	30	D

Test 15
Static charges

1	D	16	B
2	A	17	C
3	B	18	D
4	A	19	A
5	B	20	D
6	C	21	B
7	C	22	A
8	B	23	D
9	C	24	A
10	A	25	D
11	B		
12	D		
13	E		
14	K		
15	K		

Test 16
**Electric field and
potential difference**

1	D	16	D
2	B	17	D
3	D	18	A
4	A	19	A
5	C	20	C
6	C	21	B
7	B	22	D
8	A	23	B
9	B	24	D
10	B	25	C
11	A	26	A
12	C	27	C
13	B	28	A
14	D	29	A
15	C		

Test 17
Current electricity

Test 18
The magnetic field

1	A	16	B
2	B	17	C
3	B	18	B
4	A	19	D
5	C	20	A
6	D	21	B
7	D	22	A
8	B	23	A
9	C	24	D
10	C	25	C
11	A	26	D
12	D	27	B
13	C		
14	A		
15	C		

1	A	16	B
2	C	17	A
3	B	18	D
4	D	19	D
5	A	20	D
6	A	21	B
7	C	22	C
8	B	23	C
9	D	24	D
10	C	25	C
11	B		
12	D		
13	A		
14	B		
15	A		

Test 19
Induced EMF

Test 20
Atomic physics

1	B	16	B
2	C	17	C
3	B	18	A
4	A	19	D
5	A	20	D
6	D	21	A
7	D	22	D
8	B	23	B
9	D	24	C
10	A	25	C
11	A	26	H
12	C		
13	C		
14	B		
15	A		

1	A	16	A
2	B	17	A
3	D	18	C
4	D	19	D
5	A	20	B
6	C	21	D
7	B	22	A
8	D	23	C
9	B	24	D
10	C	25	B
11	A	26	D
12	D	27	C
13	A	28	C
14	B	29	A
15	B		

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Test 21
Quantum physics

1	A	16	D
2	B	17	C
3	D	18	B
4	D	19	A
5	B	20	D
6	C	21	D
7	C	22	B
8	B	23	C
9	C	24	D
10	D	25	A
11	C	26	C
12	B		
13	B		
14	C		
15	D		

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